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AN 02-35GC-2

SERVICE INSTRUCTIONS

R-1820-40, -40B, -54, -60, -65 -71, -73, -87 and -97

AIRCRAFT ENGINES

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General.

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LIST OF REVISED PAGES ISSUED

NOTE: A heavy black vertical line, to the left of the text on revised pages, indicates the extent of the revision. This line is omitted where more than 50 percent of the page is revised.

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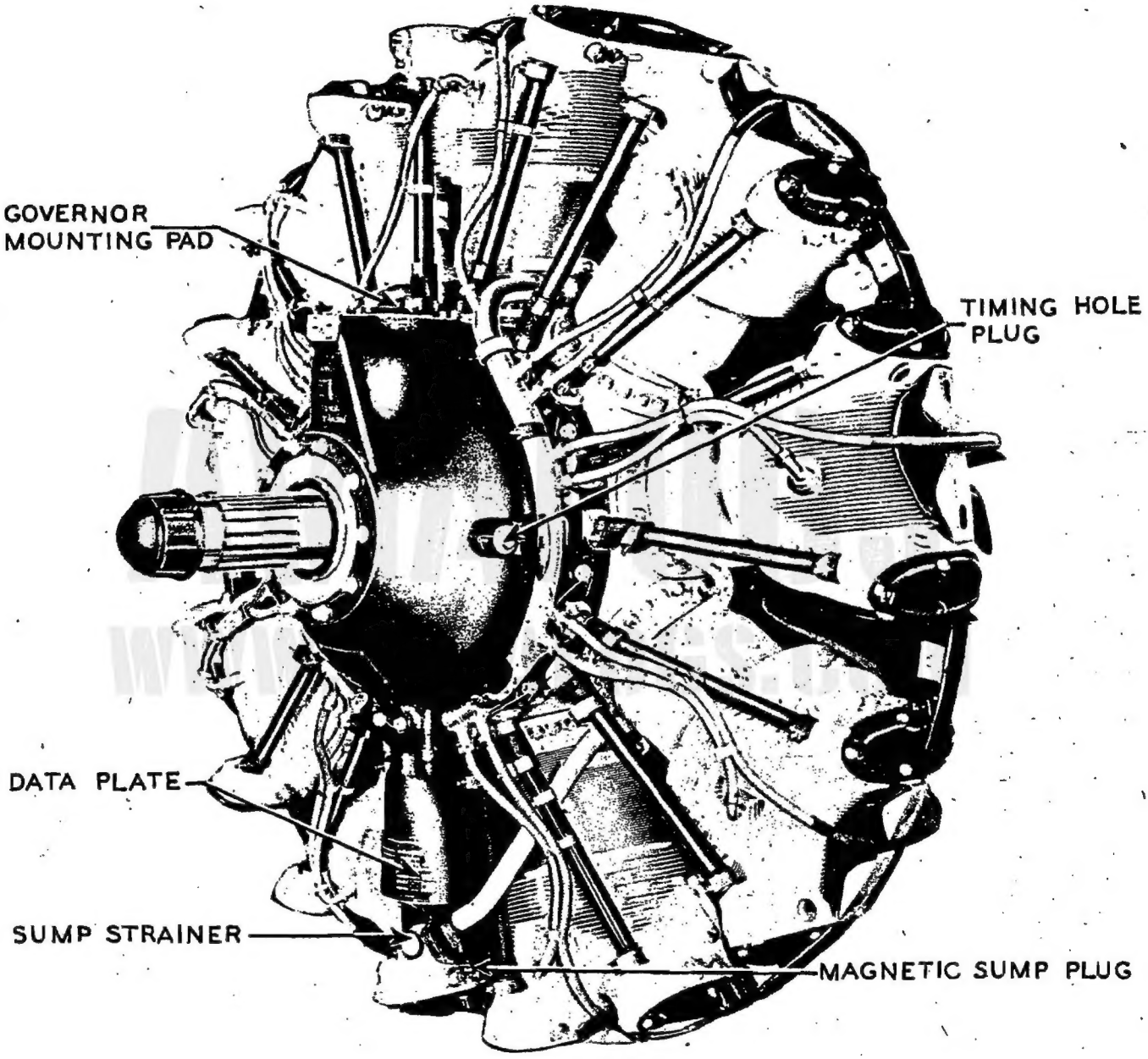

Figure 1—Three-Quarter Left Front View R-1820-65

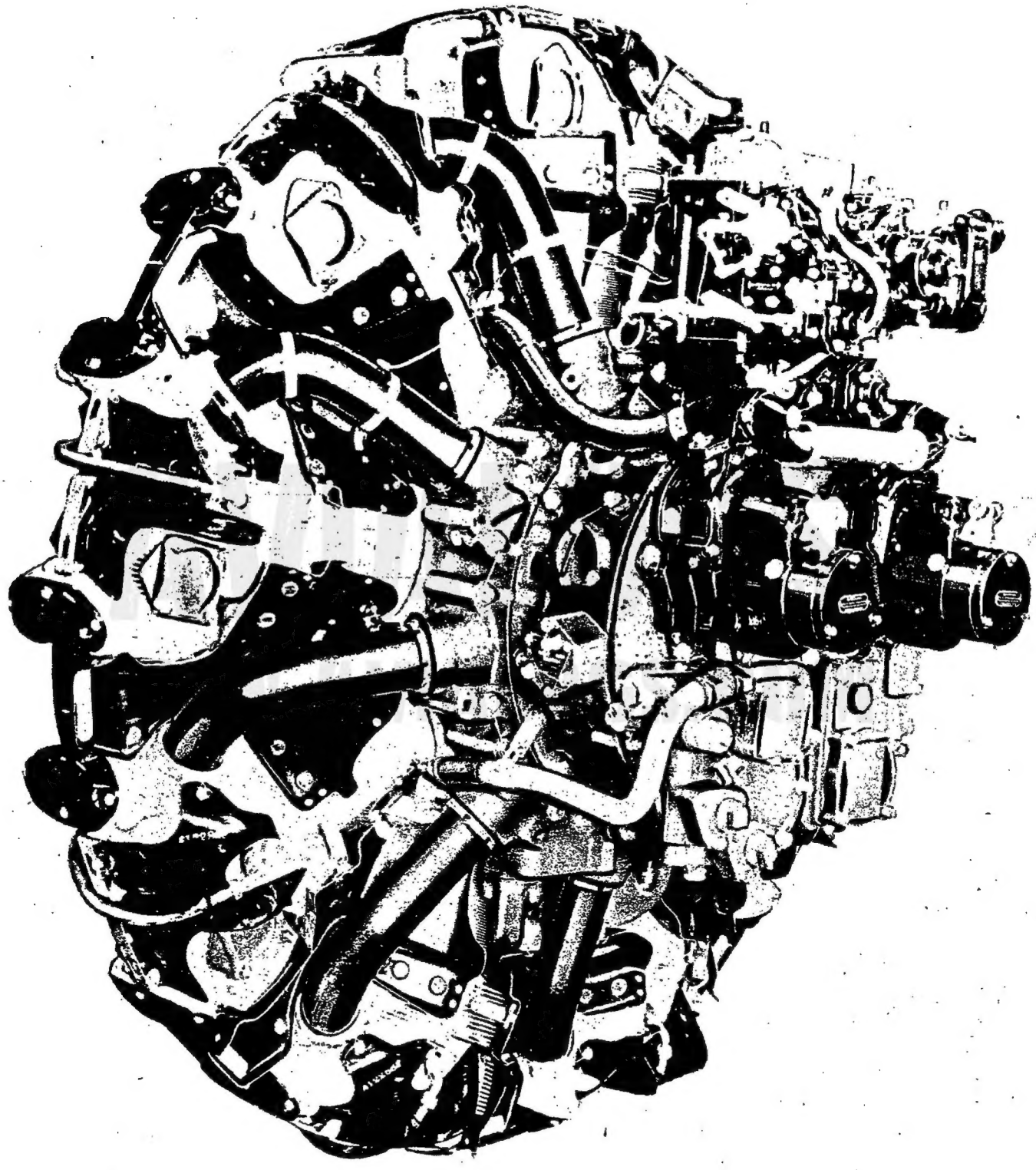

Figure 2—Three-Quarter Left Rear View R-1820-65

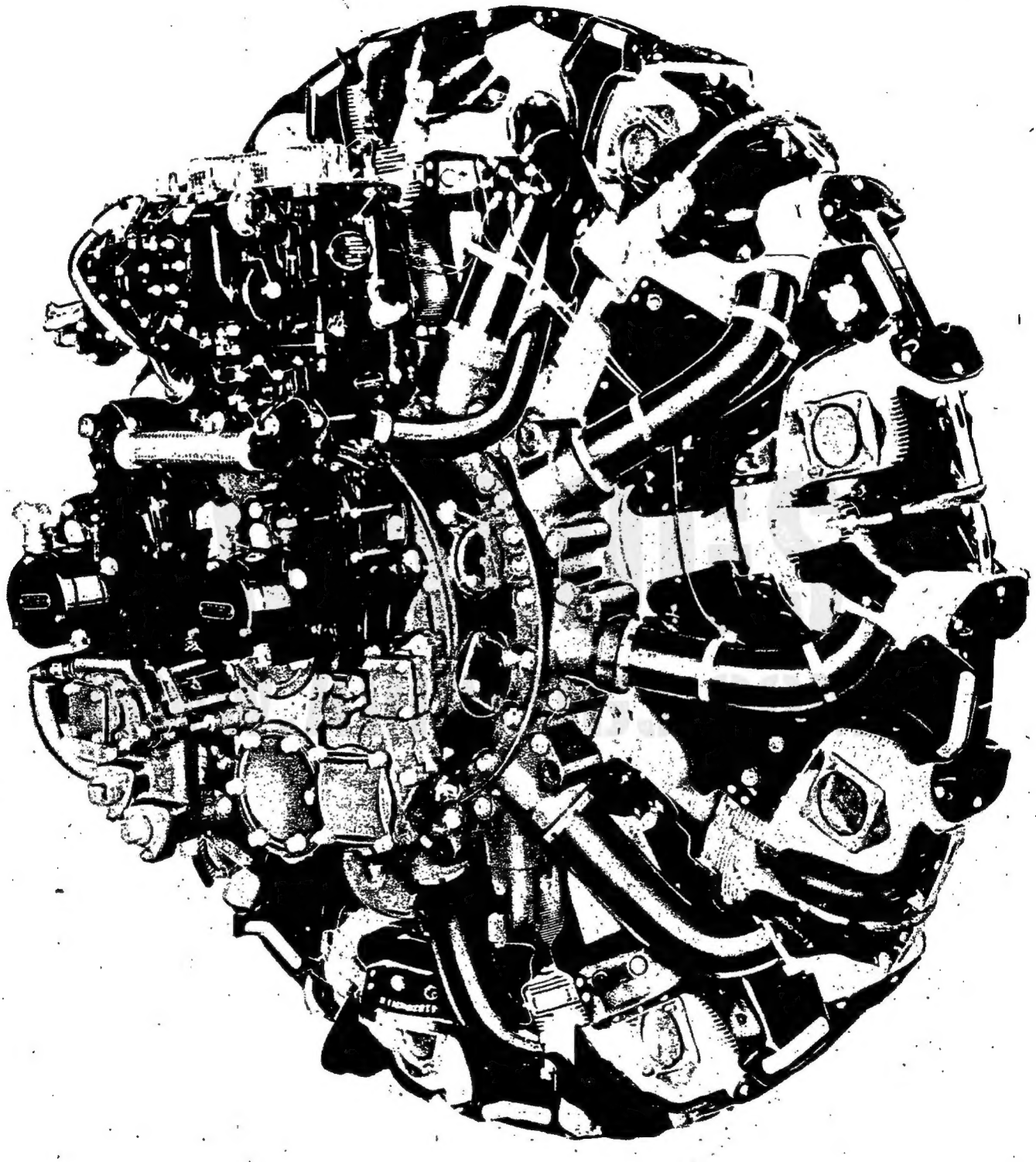

Figure 3—Three-Quarter Right Rear View R-1820-65

SECTION I
INTRODUCTION

1. This publication comprises the Service Instructions for the Model R-1820-65 engine and associated models manufactured by Wright Aeronautical Corporation, Paterson, New Jersey.

2. In this publication the following definitions will be used:

a. The *Front* of the engine refers to the propeller end.

b. The *Rear* of the engine refers to the antipropeller end.

c. The *Right* and *Left* sides of the engine refer to the viewpoint of an observer facing the antipropeller or rear end of the engine.

d. The rotation of the crankshaft and propeller shaft is clockwise when viewed from the rear of the engine.

e. The terms *Clockwise* and *Counterclockwise,* in respect to accessories, refer to the viewpoint of an observer facing the accessory drive.

f. The cylinders are numbered consecutively in the direction of crankshaft rotation; that is, clockwise as viewed from the rear of the engine. The top cylinder is designated as cylinder No. 1. See figure 4.

g. The *Horizontal Position* refers to the position of the engine in level flight.

3. All these engines are single-row, nine-cylinder, air-cooled, static radial-type engines operating on the conventional four-stroke cycle.

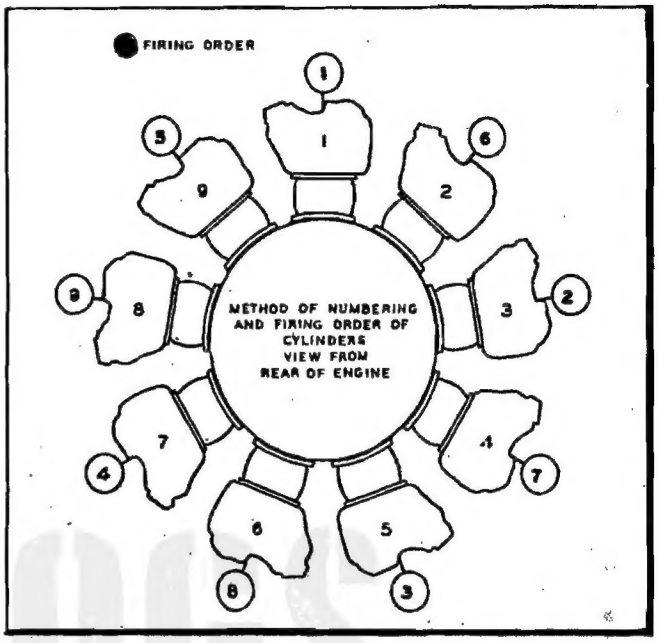

Figure 4—Cylinder Numbering Diagram

4. The crankcase is composed of six principal sections: the magnesium alloy front section, the steel front and rear main sections, supercharger front housing, supercharger rear housing, and supercharger rear housing cover. See figure 5. The crankcase front section is attached to the crankcase front main section by cap screws. The crankcase main section halves are bolted

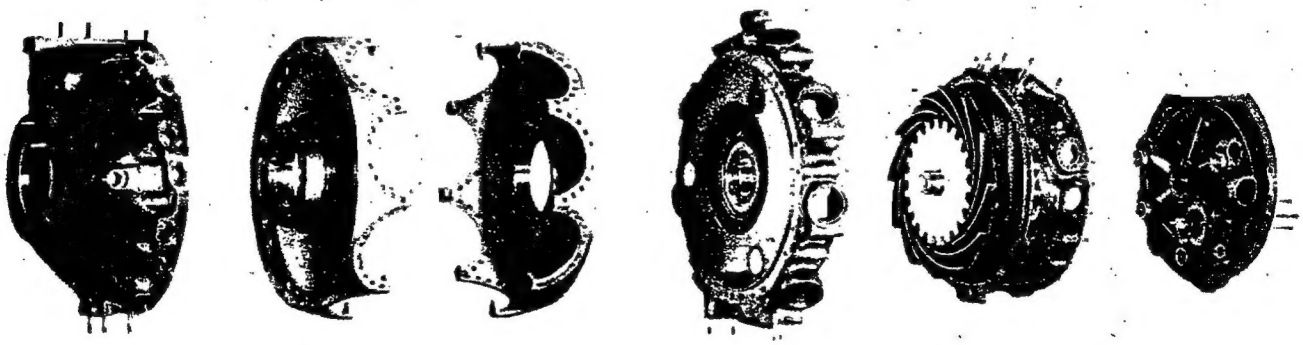

Figure 5—Crankcase Sections—Exploded View

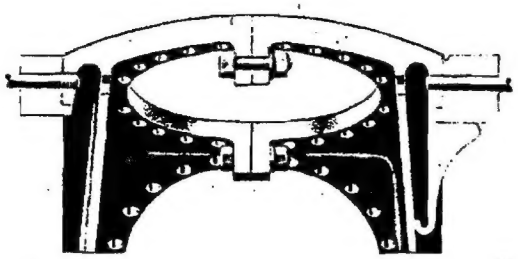

Figure 6—Method of Joining the Crankcase Main Section Halves

together internally at the center side of the cylinder holes. See figure 6. The supercharger front housing is attached to the crankcase rear main section by means of cap screws. The supercharger rear housing is attached to the supercharger front housing by studs, washers, nuts, and palnuts. The supercharger rear housing cover is secured to the rear housing by studs, washers, nuts, and palnuts.

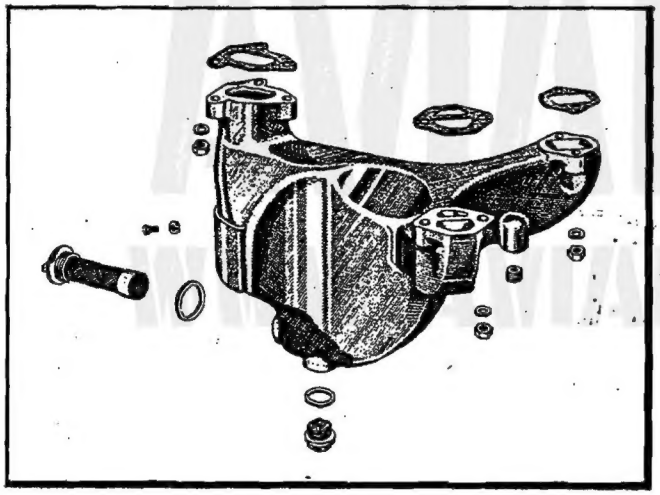

Figure 7—Oil Sump

5. The oil sump is attached to the bottom of the crankcase front section and the supercharger front housing. See figure 7.

6. The cylinders are attached to the crankcase main sections by means of 20 cylinder hold-down cap screws in four groups of five each. The major parts of the cylinder assembly consist of the cylinder head which is shrunk and screwed on to the finned barrel, the piston and piston pin with spring-type retainers, and the piston rings. See figure 8. The poppet-type intake and exhaust valves, which are located in guides shrunk in the cylinder head, are operated by a mechanism consisting of rocker arms, push rods, and valve tappets.

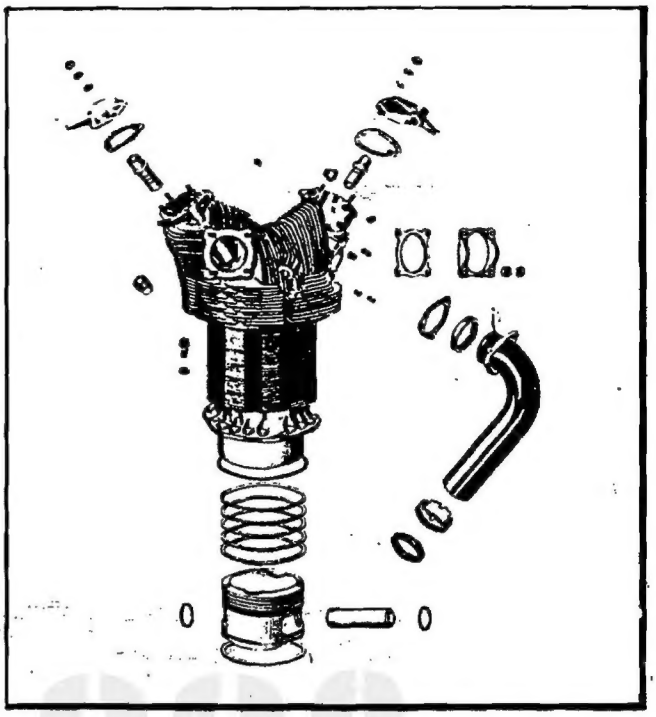

Figure 8—Cylinder, Intake Pipe, Piston, and Piston Rings

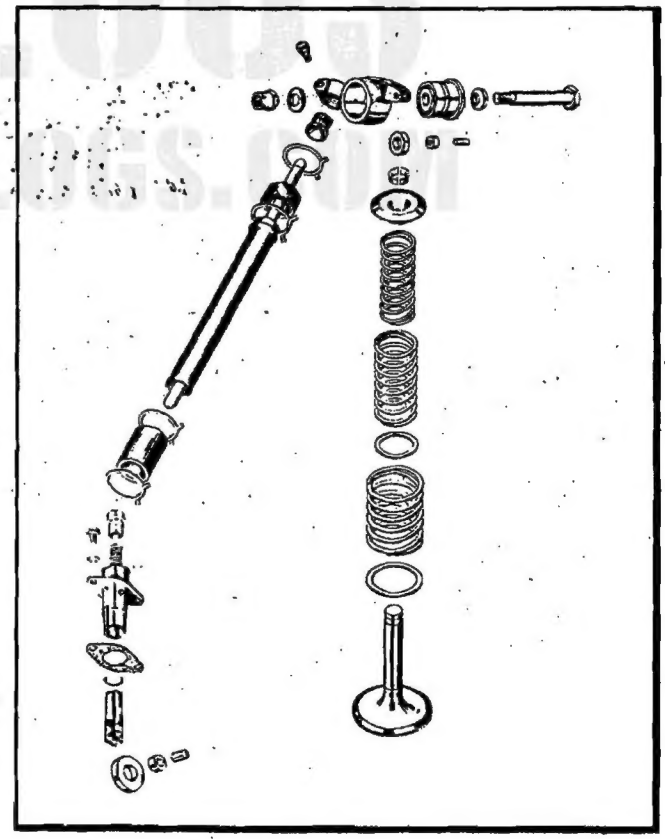

Figure 9—Valve Operating Mechanism

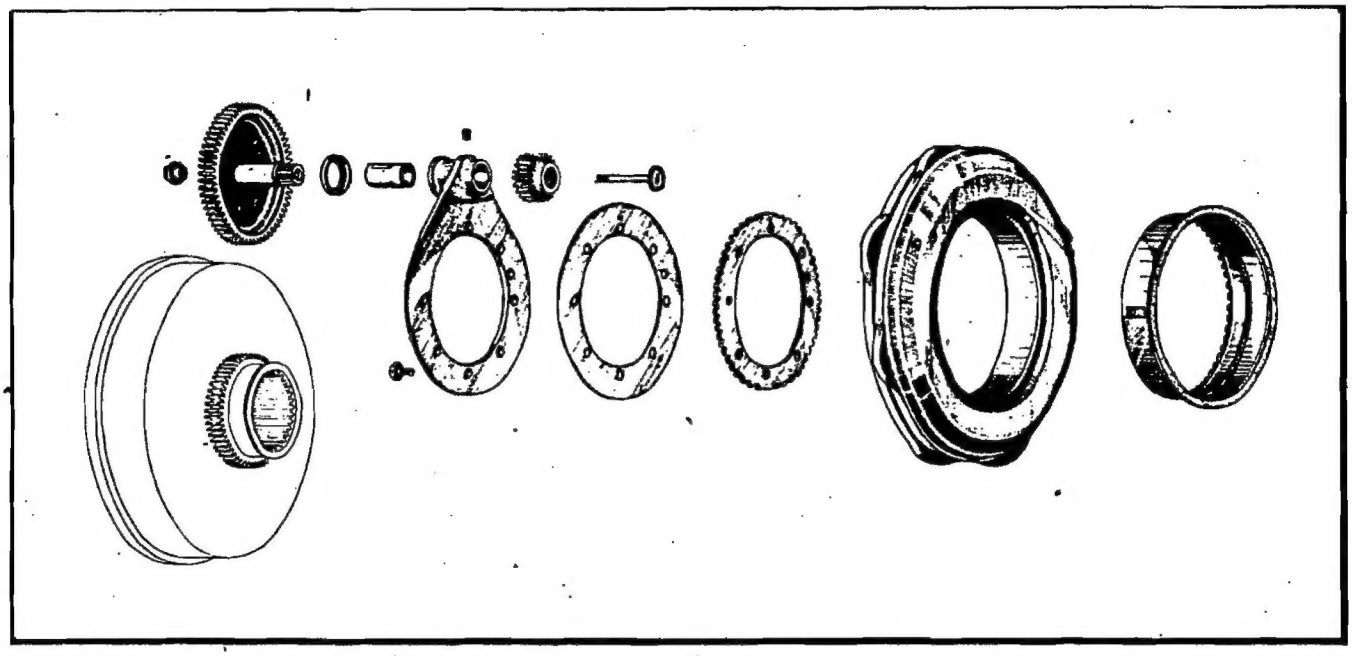

Figure 10—Cam and Cam Drive

See figure 9. The tappets are actuated by lobes on a cam ring driven from a step-down gear train originating at the crankshaft. See figure 10. Each valve is closed by three concentric coil springs.

7. The crankshaft is of two-piece design. The front section of the shaft includes the crankpin, the front crankcheek, front dynamic damper counterweight, the front main bearing journal, and the front extension. The rear section includes the rear crankcheek, the rear dynamic damper counterweight, and the crankshaft rear main bearing journal. See figure 11. The dynamic damper counterweights are each supported by two floating pins which pass through the extended portions of the crankcheeks. The bushings on the rear counter-

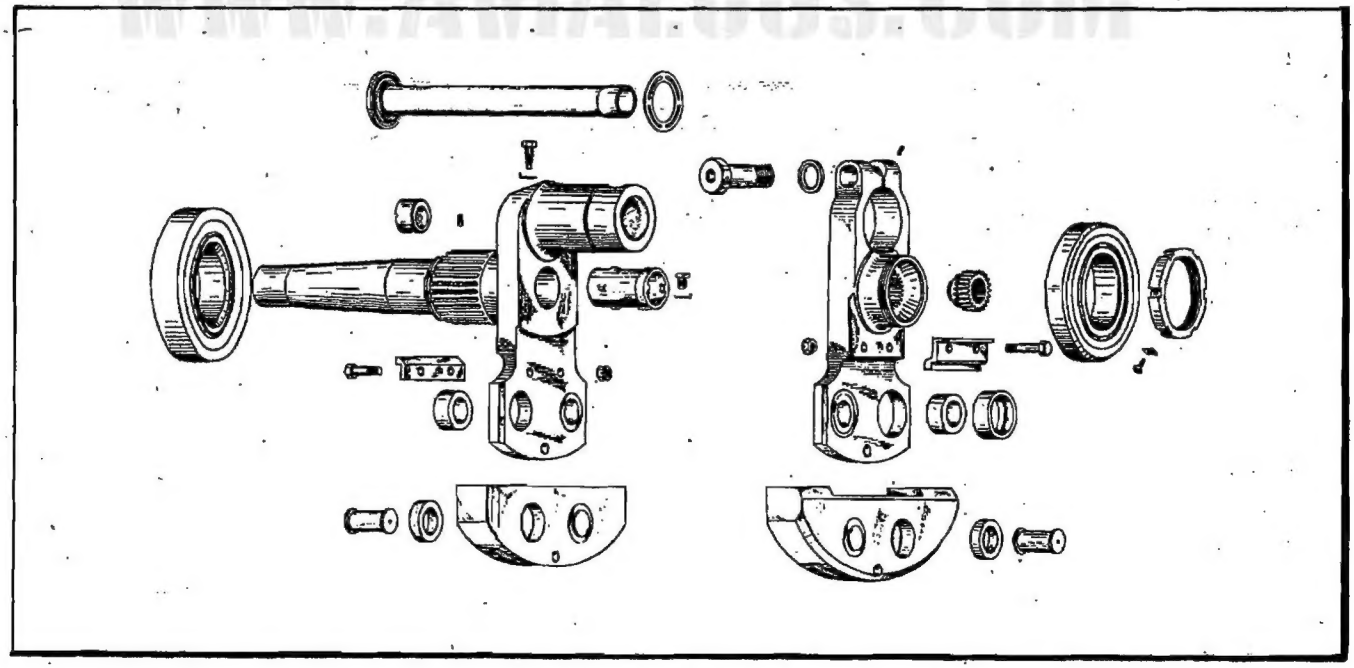

Figure 11—Crankshaft

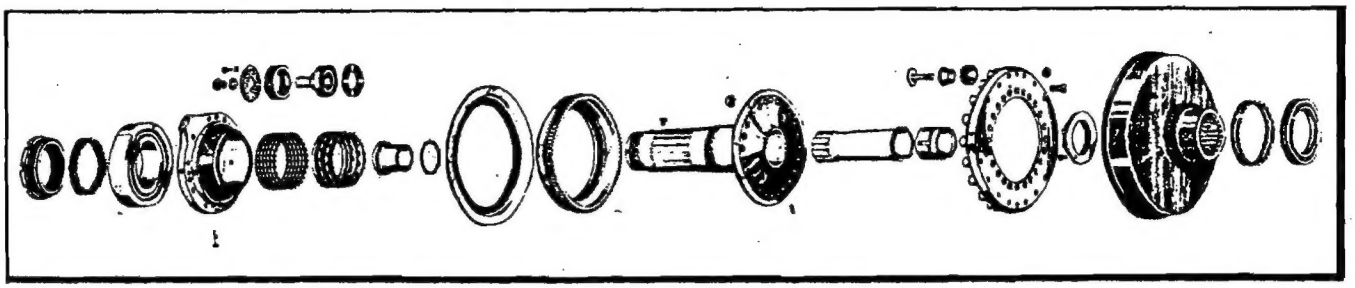

Figure 12—Propeller Shaft and Reduction Gear (16:9 Reduction)

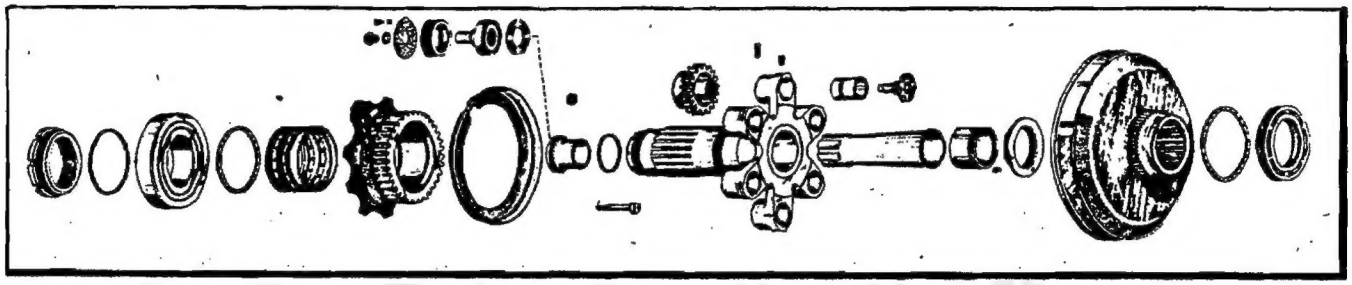

Figure 13—Propeller Shaft and Reduction Gear (3:2 Reduction)

weight are of the floating type. When the propeller is rotated slowly by hand and the counterweights rise above the horizontal position, the dynamic dampers fall against stops on the crankshaft. The resulting noise is in some cases clearly audible and is brought to the attention of operators in order to prevent unnecessary investigation. The forward end of the crankshaft extends inside the propeller shaft. The propeller shaft, in all models except the R-1820-54, is driven by reduction gearing of 16:9 or 3:2 ratio. See figures 12 and 13. The R-1820-54 is a direct drive engine. In this case, the propeller shaft is attached to the crankshaft by means of a bell-shaped coupling which is splined to the crankshaft in place of the reduction gear on geared engines.

8. The articulated rod assembly is attached to the crankshaft by the master rod. See figure 14. Eight articulated rods are connected to the master rod by means of knuckle pins. The opposite ends of master and articulated rods are attached to pistons which ride inside the cylinders.

9. The supercharger consists of an impeller, diffuser plate, and distribution chamber. R-1820-40, -40B, -54, -60, and -87 engines are equipped with two-speed superchargers with roller- or plate-type clutches. See figures 15 and 16. The R-1820-65, -71, -73, and -97 engines are equipped with single-speed supercharger drives. See figure 17.

10. The magnetos, generator, starter, fuel pump, oil pump, and other accessories are driven by a series of gears which are located in the supercharger rear housing. See figure 18.

11. The lubrication system is of the full pressure type except for the cylinder walls, piston pins, crankshaft main bearings, and propeller shaft thrust bearing, all of which are lubricated by splash. See figure 19.

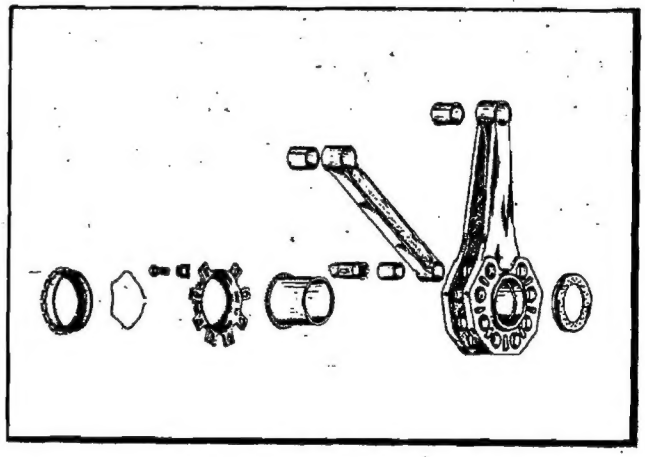

Figure 14—Master and Articulated Rods and End Seal Assembly

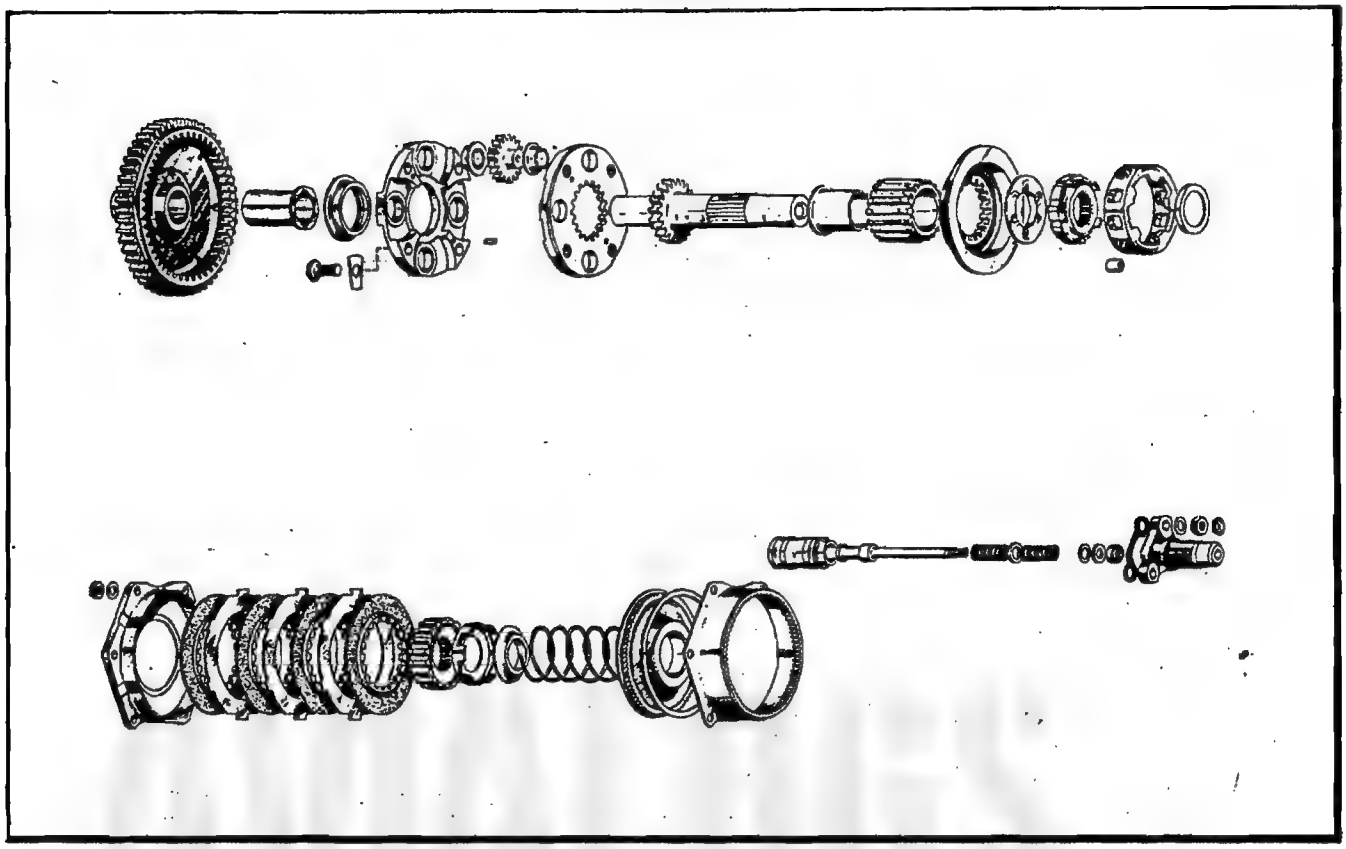

Figure 15—Supercharger Drive, Two-Speed (Roller Clutch)

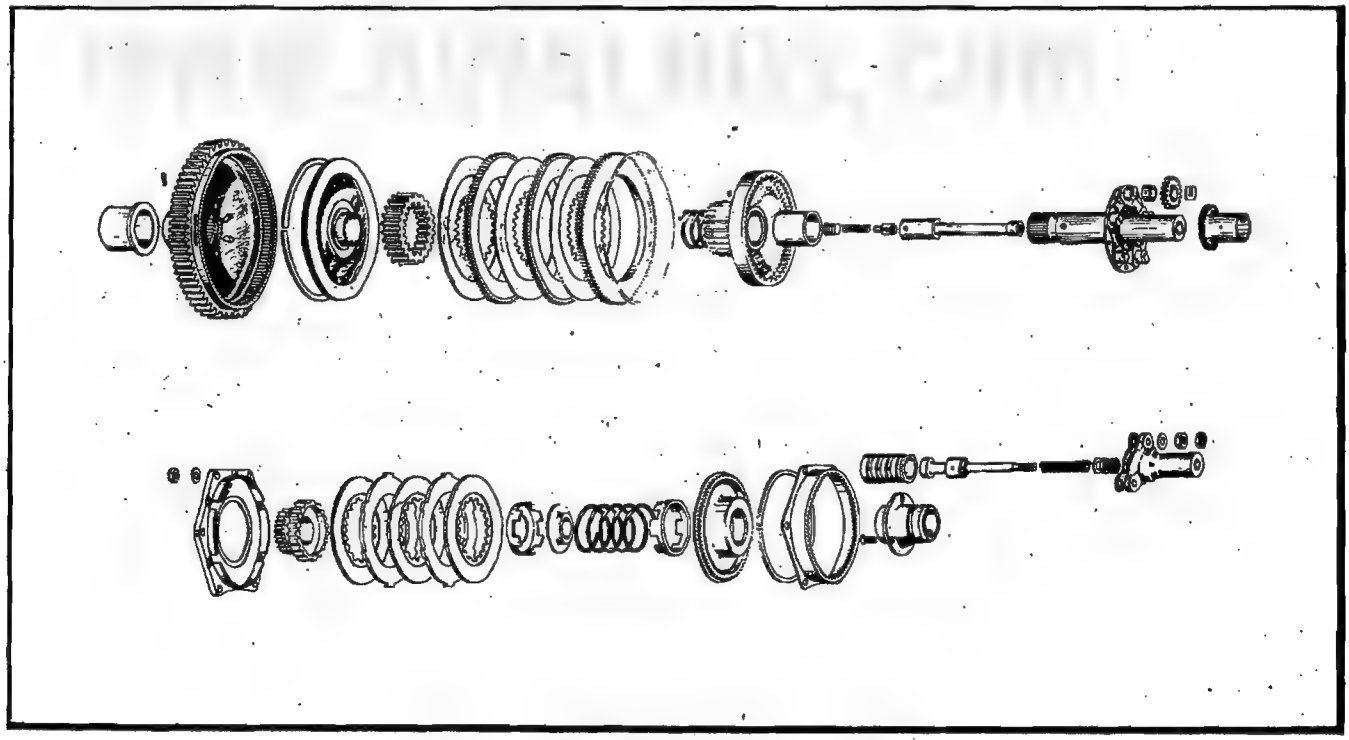

Figure 16—Supercharger Drive, Two-Speed (Plate Clutch)

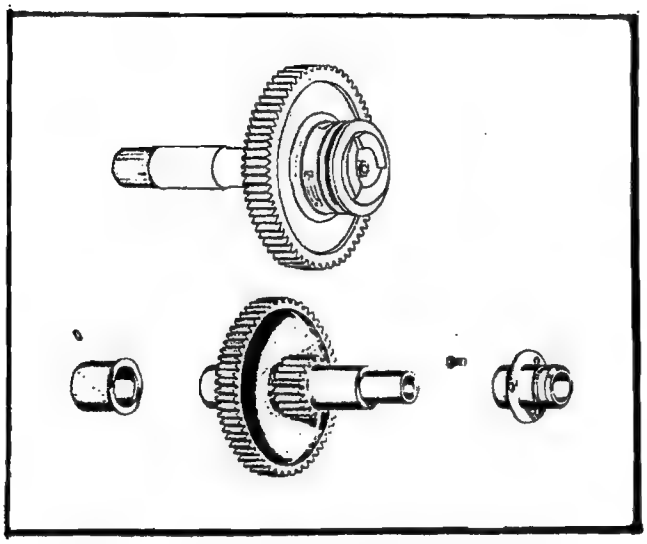

Figure 17—Supercharger Drive, Single-Speed

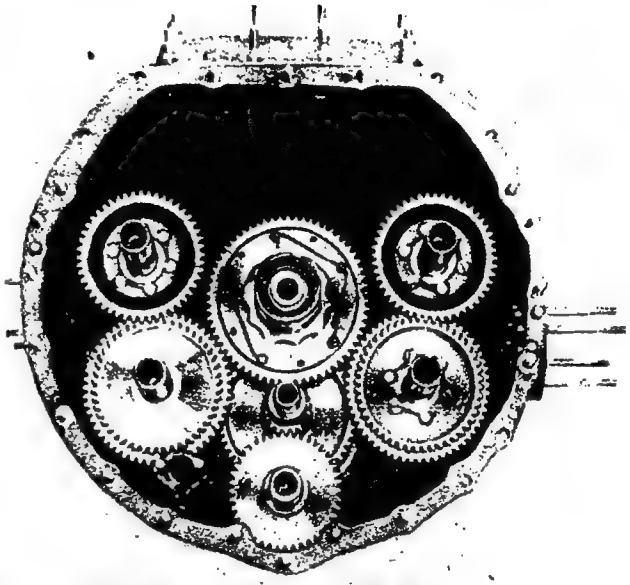

Figure 18—Location and Direction of Rotation of Accessory Drive Gears

NOTE

The following Service Publications contain related instructions for use by Army personnel and are listed only for convenient reference in the event further information is required:

No.	
00-1	Index of Technical Instructions and Information
00-20A	The Army Air Forces Visual Inspection System for Airplanes
02-1-1	Preparation of Engines for Storage
02-1-6	Periodic Inspection and Adjustment of Valve Mechanisms
02-1-9	Soldering Shielded Ignition Manifolds
02-1-14	Equipment Comprising "Complete Aircraft Engine"
02-1-28	Inspection and Tightening of Intake Pipe Packing Nuts
02-1-34	Tightening Crankshaft and Propeller Shaft Thrust Bearing Nuts
02-1-55	Tightening of Cylinder Hold-Down Nuts and Cap Screws—Air-Cooled Radial Engines
02-35-1	Table of Limits—Wright Engines
02-35-2	Service Tools Catalog
03-5DC-1	Handbook of Instructions with Parts Catalog—Types SB9RU-3, SF9LU-3, SF14LU-6, SF14LU-7, and SF14LC-7
03-5E-1	Spark Plugs—Use and Reconditioning
03-10BA-2	Handbook of Service Instructions—Injection Carburetors
03-20CA-2	Service and Overhaul Instructions with Parts Catalog for Propeller Governors
05-40-10	Cold Weather Operation of Oil Pressure Gages
06-10-1	Aircraft Engine Lubricating Oils—Grades and Use
08-5-1	Shielding and Bonding of Aircraft

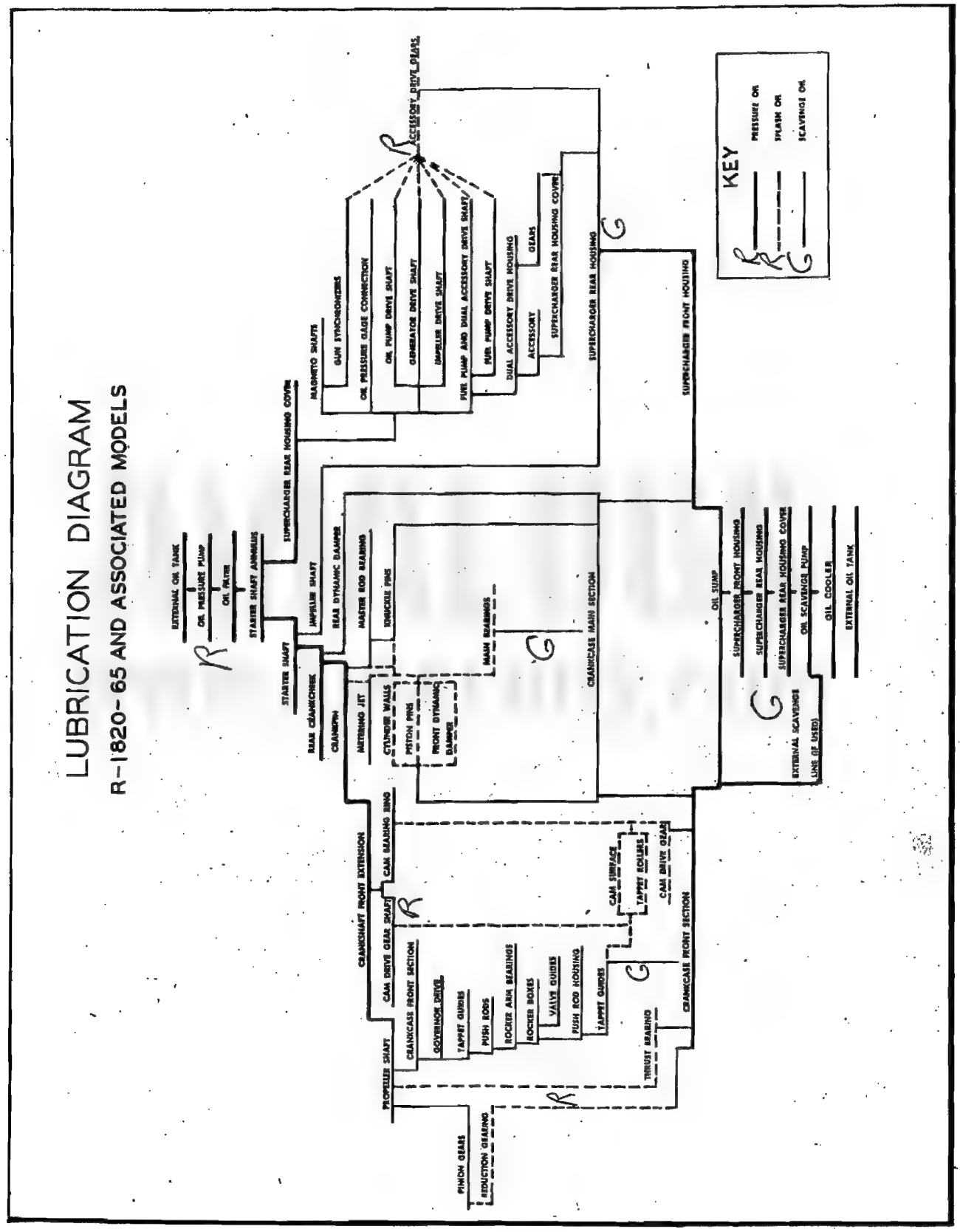

Figure 19—Lubrication Diagram

SECTION II

TABLE OF SPECIFICATIONS

Models	R-1820-40, -40B, -54, -60, -65, -71, -73, -87, and -97
Type	Single-Row, Static Radial, Air-Cooled
Number of Cylinders	9
Bore	6.125 in.
Stroke	6.875 in.
Piston Displacement	1823 cu in.
Compression Ratio	6.70:1
Impeller Gear Ratio:	
R-1820-40, -40B, -54, -60, -87 (Roller-Type Clutch)	7.13:1 and 10.04:1
R-1820-40, -87 (Plate-Type Clutch)	7.14:1 and 10.00:1
R-1820-65, -71, -73, -97	7.00:1
Impeller Diameter	11.0 in.
Rated Speed in rpm	
R-1820-40, -40B, -60, -65, -71, -73, -87, -97	2300
R-1820-54	2100
Rated bhp/rpm at Sea Level	
R-1820-40, -40B, -60, -65, -71, -73, -87, -97	1000/2300
R-1820-54	900/2100
Rated bhp/rpm at 6900 ft (Low Ratio)	
R-1820-40, -40B, -60, -71, -87	1000/2300
Rated bhp/rpm at Altitude (25,000 ft)	
R-1820-65, -73, -97	1000/2300
Rated bhp/rpm 4700 ft (Low Ratio)	
R-1820-54	900/2100
Rated bhp/rpm at 15,200 ft (High Ratio)	
R-1820-40, -40B, -60, -87	900/2300
Rated bhp/rpm at 14,100 ft (High Ratio)	
R-1820-54	800/2100
Take-off bhp/rpm at Sea Level	
R-1820-40, -40B, -60, -65, -71, -73, -87, and -97	1200/2500
R-1820-54	1050/2200
Military Rated bhp/rpm at 4200 ft (Low Ratio)	
R-1820-87	1200/2500
Military Rated bhp/rpm at 14,200 ft (High Ratio)	
R-1820-87	1000/2500
Rotation of Crankshaft	Clockwise
Rotation of Propeller	Clockwise
Propeller Reduction Gear Ratio	
R-1820-40, -40B, -60, -71, -73, -87	.666 (3:2)
R-1820-65, -97	.5625 (16:9)
R-1820-54	Direct Drive
Propeller Shaft Spline Size	SAE No. 50

Average Weight of Engine	
R-1820-40, -40B, -60, -87	1315 lb
R-1820-65, -71, -73, -97	1308 lb
R-1820-54	1265 lb
Overall Length of Engine	
R-1820-40, -40B	48.40 in.
R-1820-54	46.96 in.
R-1820-60	47.59 in.
R-1820-71	50.04 in.
R-1820-65, -73, -87, -97	48.22 in.
Position of Center of Gravity	
Distance Aft of Thrust Nut Front Face	
R-1820-40, -40B, -60	14.91 in.
R-1820-54	15.42 in.
R-1820-65, -73, -97	14.76 in.
R-1820-71, -87	14.90 in.
Distance Forward of Rear Face of Mounting Bosses	
R-1820-40, -40B, -60	7.24 in.
R-1820-54	6.74 in.
R-1820-65, -73, -97	7.38 in.
R-1820-71, -87	7.50 in.
Distance Above Center Line of Crankshaft	
R-1820-40, -40B, -60	.20 in.
R-1820-54	.47 in.
R-1820-65, -73, -97	.26 in.
R-1820-71, -87	.375 in.
Diameter of Mounting Bolt Circle	
R-1820-40, -40B, -60, -65, -71, -73, -87, -97	23.37 in.
R-1820-54	23.370-23.380 in.
Number of Mounting Bolts	9
Overall Diameter of Engine	
R-1820-40, -40B, -60, -65, -73, -97	55.12 in.
R-1820-54	54.71-54.95 in.
R-1820-71, -87	55.10 in.

IGNITION

Magneto Type	
R-1820-40, -40B, -65, -71, -73, -87, -97	Scintilla SF9LN4
R-1820-60, -65, -97	Bosch SF9LU3
R-1820-54	Edison Splitdorf SF9LD-1
Rotation of Magneto Drive	Clockwise
Magneto Drive Shaft Speed Ratio to Crankshaft	1.125:1
Spark Plug Gap	.012 in.
Spark Timing on No. 1 Cylinder	
Left Magneto (Rear Plugs)—Degrees BTC	20 deg
Right Magneto (Front Plugs)—Degrees BTC	20 deg

VALVES AND TIMING

Intake Opens—Degrees BTC	15 deg
Intake Closes—Degrees ABC	44 deg
Exhaust Opens—Degrees BBC	74 deg
Exhaust Closes—Degrees ATC	25 deg
Intake Remains Open, Crankshaft Degrees	239 deg
Exhaust Remains Open, Crankshaft Degrees	279 deg
Valve Lift	.562 in.
Valve Rocker Clearance—Cold	.010 to .017 in.
Timing Clearance (Cold)	.075 in.
Adjusting Clearance (Cold)	.075 in.

FUEL SYSTEM

Carburetor Type
- R-1820-40, -40B, -54, -71, -87: Bendix Stromberg Injection PD12H3
- R-1820-60: Bendix Stromberg Injection PD12K4
- R-1820-65, -73, -97: Bendix Stromberg Injection PD12H2

Fuel
- Air Corps Specification
  - R-1820-40, -40B, -60, -65, -71, -73, -87, -97: AN-VV-F-781
  - R-1820-54: AN-VV-F-781 and N5
- Octane: 100

Fuel Inlet Connection—Thread: 3/4"-in. Std Pipe Tap

Supercharger Drain Valve Connection—Thread: .250-in. Std Pipe Tap

Primer Connection
- R-1820-40, -54, -60, -65, -71, -73, -87, -97: .125-in. Std Pipe Tap
- R-1820-40B: .428 20 USF with .25 OD Tubing

LUBRICATION SYSTEM

Grade of Oil Desired in Flight—Specification: AN-VV-O-446, Grade 1120

Rotation of Oil Pump Drive Shaft: Counterclockwise

Oil Pump Inlet Flange Connection—Thread
- R-1820-40: .750 in.
- R-1820-40B, -54, -60: Provision for AN 4037
- R-1820-65, -71, -73, -87, -97: 1 in.

Oil Pump Outlet Flange Connection—Thread
- R-1820-40, -65, -73, -97: .750 in.
- R-1820-40B, -54, -60: Provision for AN 4037
- R-1820-71, -87: 1 in.

Oil Vent Connection—Thread
- R-1820-40, -40B, -54, -60, -65, -73, -87, -97: .750 in.
- R-1820-71: .375 in.

ACCESSORY DRIVES

Dual Accessory Drive

Upper Mount: Four .250-in.—28 USF Studs .78 in. High, Spaced 1.875 x 1.875 in.

Upper Drive: 12-Tooth Involute Spline .600 in. PD or Tongue .55 x .10 in.

Upper Drive Speed Ratio to Crankshaft: 1.5:1

Upper Drive Rotation: Counterclockwise

Lower Drive Mount: Four .313 in.—24 USF Studs .82 in. High, Equally Spaced on 5 in. Diam Circle

Lower Drive
- R-1820-40, -40B, -54, -60, -71, -87: 12-Tooth Involute Spline .600 in. PD
- R-1820-65, -73, -97: 6 Square Splines .878 in. OD-.698 in. ID

Lower Drive Speed Ratio to Crankshaft: 1.5:1

Lower Drive Rotation: Counterclockwise

Fuel Pump Mount: Four Run Fit .313 in.—USF Studs .88 in. High, Spaced 2 x 2 in.

Fuel Pump Drive: 11-Tooth Involute Spline—.4583 in. PD

Fuel Pump Speed Ratio to Crankshaft: 1:1

Fuel Pump Rotation: Counterclockwise

Generator Mount: Six .375 in.—24 USF Studs .94 in. High, Equally Spaced on 5 in. Diam Circle

Generator Drive: 16-Tooth Involute Spline—.800 in. PD

Generator Drive Speed Ratio to Crankshaft: 1.5:1

Generator Drive Rotation: Clockwise

Gun Synchronizer Drive Speed Ratio to Crankshaft
- R-1820-40, -60, -71, -73: 2:3
- R-1820-65, -97: 9:16

Gun Synchronizer Rotation
- R-1820-40, -60, -65, -71, -73, -97: Left, Clockwise Right, Counterclockwise

Propeller Governor Mount
- R-1820-40, -40B, -60, -87: Four .313 in.—24 USF Studs .88 in. High, Spaced 2.125 x 2.125 in.
- R-1820-65, -71, -73, -97: Four .313 in.—24 USF Studs .94 in. High, Spaced 2.125 x 2.125 in.
- R-1820-54: Four .313 in.—24 USF Studs 1 in. High, Spaced 2.125 x 2.125 in.

Propeller Governor Drive: 12 Involute Splines—.600 in. PD

Propeller Governor Drive Speed Ratio to Crankshaft: 1:1

Propeller Governor Drive Rotation: Clockwise

Starter Mount	Six .375 in.—24 USF Studs .94 in. High, Equally Spaced on 5 in. Diam Circle
Starter Drive	
R-1820-40, -40B, -54, -60	12-Jaw Detachable Dog
R-1820-65, -71, -73, -87, -97	3-Jaw Detachable Dog
Starter Speed Ratio to Crankshaft	1:1
Starter Rotation	Clockwise
Tachometer	
Left (Electrical) Mount	
R-1820-40, -40B, -65, -71, -73, -87, -97	Four .250 in.—28 USF Studs .68 in. High, Spaced 1.875 x 1.875 in.
Drive	.250-in. Square Hole
Right (Mechanical) Thread	.875 in.—18 USF
Tachometer Shaft Rotation	Clockwise
Tachometer Shaft Speed Ratio to Crankshaft	.5:1

INSTRUMENT CONNECTIONS

Air Scoop Pressure Connection Carburetor Flange Thread	.125-in. Std Pipe Tap
Fuel Pressure Regulator Vent Connection	.125-in. Std Pipe Tap
Manifold Pressure Connection (Upper Right Side of Rear Cover)	
Thread	.125-in. Std Pipe Tap
Fitting	No. 50 Drill
Oil Pressure Connections	
Engine, Accessory Drive and Starter Shaft	.125-in. Std Pipe Tap
Engine, Propeller End	.125-in. Std Pipe Tap
Torquemeter (Engines Supplied with Torquemeter) R-1820-40, -40B, -60, -65, -73, -87, -97	.125-in. Std Pipe Tap
Oil Inlet and Outlet Thermometer Connection Thread	.625 in.—18 USF
Thermocouple, Spark Plug Type—Thread R-1820-65, -71, -73, -97	No. 12—28 USF

ACCESSORIES AND WEIGHTS

Standard Equipment	*Weight*
Carburetor, Bendix Stromberg Injection PD12H3 (Complete)	45.00 lb
Carburetor, Bendix Stromberg Injection PD12H2 (Complete)	45.00 lb
Carburetor, Bendix Stromberg Injection PD12K4	45.00 lb
Magnetos, Scintilla SF9LN4 (Shielded)	
R-1820-40, -40B	37.30 lb
R-1820-65, -73, -87, -97	33.00 lb
Magnetos, Scintilla SF9L4 (Shielded)	33.00 lb
Magnetos, Bosch SF9LU3	33.00 lb
Magnetos, Edison Splitdorf SF9LD1	20.40 lb
Ignition Wiring (Shielded)	20.00 lb
Spark Plugs	5.00 lb
Priming System R-1820-54, -65, -71, -73, -97	2.00 lb
Exhaust Flanges R-1820-40, -40B, -60, -65, -71, -73, -87, -97	4.00 lb
Cylinder Air Deflectors	20.00 lb
Accessory Drive Covers	2.00 lb
Total Dry Weight	
R-1820-40, -40B, -60, -87	1315.00 lb
R-1820-71, -73	1310.00 lb
R-1820-65, -97	1308.00 lb
R-1820-54	1265.00 lb
Tool Kit	18.00 lb

SECTION III

PACKING, UNPACKING, AND PREPARATION FOR STORAGE

1. GENERAL.

a. The information contained in this section is the result of extensive study and research in the prevention of corrosion in engines. The procedures outlined are a result of these studies. While complete compliance with the instructions given may at times be impracticable, the more closely they are followed, the less probability there will be of corrosion and the failure of engine parts caused by corrosive action.

b. The mixture specified in this publication consists of *one part* corrosion-preventive compound, conforming to AN-VV-C-576, in *three parts* of aircraft engine lubricating oil, conforming to AN-VV-O-446.

CAUTION

The corrosion-preventive compound will never be used unless mixed with lubricating oil in the specified ratio.

2. SHIPPING BOXES.

a. GENERAL CONSTRUCTION.—Shipping boxes for these engines are constructed in two sections: a cradle on which the engine is mounted and in which unattached parts are stored, and a cover which is bolted to the cradle. Both the cover and the cradle are constructed of sound pine or spruce wood. Cradle members of 2-¾ inch thickness are bolted to the bottom of the box with through bolts to form a support for a rugged steel mount plate which is attached to the mounting lug section of the engine. The sides and top of the box are constructed of single-ply matched tongue and groove ⅞ inch board, amply reinforced with cross strips of the same thickness. The cradle is lined with three-ply asphalt felt, has a layer of this material between the bottom boards, and is painted completely. The unlined cover is painted on the external surfaces only, and is provided with two metal guards at the upper edges to protect the wood against the lifting tackle. The box rests on two skids of 2-¾ inch thickness bolted to its bottom, which is constructed of double-ply matched ⅞ inch boards. Two steel straps on each of two opposite sides of the cover form lifting hooks and provide means of bolting the cover to the cradle section. The cradle bottom outside corners are reinforced with angle iron.

b. DIMENSIONS AND WEIGHTS.

(1) The dimensions of the shipping boxes for these engines are as follows:

Length	65 Inches
Width	61 Inches
Height	59 Inches

(2) The approximate total weight of the shipping box with the engine packed for shipment is 2200 pounds.

3. CONDITIONS FOR SLUSHING.

a. All engines which are to be stored or to remain idle for periods exceeding 48 hours MUST be protected to prevent corrosion of metal parts. Protection is afforded by (1) running the engine out on unleaded fuel, (2) slushing the internal sections of the engine with the corrosion-preventive mixture, and (3) where possible, dehydrating the air in and around the engine by means of a dehydrating agent conforming to AN-D-6 and a moisture-resistant transparent plastic-film engine envelope conforming to AN-O-P-406. It is the purpose of this section to outline the procedure necessary to provide such protection and, although the chronological order of the following instructions may be changed, each operation MUST be performed. Engines not protected with envelopes MUST be reslushed at least every six months. If stored near tidewater or in a tropical climate, repeat the procedure at three-month intervals.

b. Slush engines which cannot be turned over due to internal failure in any practical manner to keep the engine parts in as good condition as possible.

c. When accessories are removed from the engine, treat them as recommended by their manufacturers. Coat the mounting pad recesses with slushing mixture consisting of three parts of lubricating oil, AN-VV-O-446, and one part of slushing compound conforming to AN-VV-C-576, and seal the pads securely with moisture-resistant gaskets and substituting covers.

4. RUN-OUT AND SLUSHING PROCEDURE.

CAUTION

Do NOT commence preparing the engine for storage or shipment until it is certain that the entire procedure can be completed without delay.

a. Change the fuel to unleaded fuel, AN-F-22.

b. When changing the fuel, drain the oil from the engine and the tank. Refill with sufficient corrosion-preventive mixture for safe engine operation.

c. Run the engine for 15 minutes at 1000 rpm maximum with the propeller in low pitch, and then spray slushing mixture into the induction system, either

through the carburetor or a connection in the carburetor adapter.

d. When the exhaust smoke becomes very heavy, stop the engine immediately.

e. Remove the front spark plugs from all the cylinders and replace with vented dummy plugs.

f. Remove the magnetic sump plug and let the slushing mixture drain from the sump.

g. Remove the exhaust stacks. Coat the exhaust valves and ports with slushing mixture, and cover them with moisture-resistant seals.

h. Remove the rocker box covers and coat the rocker arm assemblies and covers with slushing mixture. Reinstall the covers.

i. Before slushing the carburetor open the throttle wide. Set the mixture control at "AUTOMATIC RICH." If not provided, set the control at "FULL RICH." Permit no slushing oil to enter the regulator air chambers, the air passages, or the automatic mixture control. These locations must be kept dry at all times.

Do NOT use air pressure to clean the carburetor.

If the carburetor is to remain installed on the engine, disconnect all fuel lines. Close the openings of the fuel lines with synthetic rubber plugs or an equivalent. Remove the drain plugs and pour lubricating oil, AN-VV-O-446, into the carburetor fuel inlet connection with the aid of a funnel, tube, and nipple. Continue this treatment until the oil draining from the carburetor is of the same consistency as that of the oil being poured into it. After the carburetor has been drained of excess oil, reinstall and lockwire the drain plugs. See figure 20.

If the carburetor is removed from the engine, treat as instructed above. Wipe the carburetor clean and lock the throttle so that it cannot be moved. Attach a one-pound bag of dehydrating agent securel, to the carburetor and seal the unit in a plastic-film envelope. See figure 21.

j. Locate the propeller shaft wide spline so that it faces the bottom of the engine. Do NOT rotate the shaft during or after the next operation.

k. Remove the vented plugs and, using a hand gun, inject a few teaspoonfuls of hot, 79° to 107°C, (175° to 225° F), slushing mixture through the spark plug holes into each combustion chamber. If the shaft has accidentally been rotated repeat operations *j.* and *k.*

l. Install the sump plug.

m. Install the regular spark plugs and connect the ignition leads.

n. The magnetos MUST be suitably protected from the washing solution.

o. Wash the engine thoroughly with a petroleum solvent conforming to Federal Specification P-S-661, or, if such solvent is not available, use kerosene, Federal Specification VV-K-211. Dry the engine with compressed air.

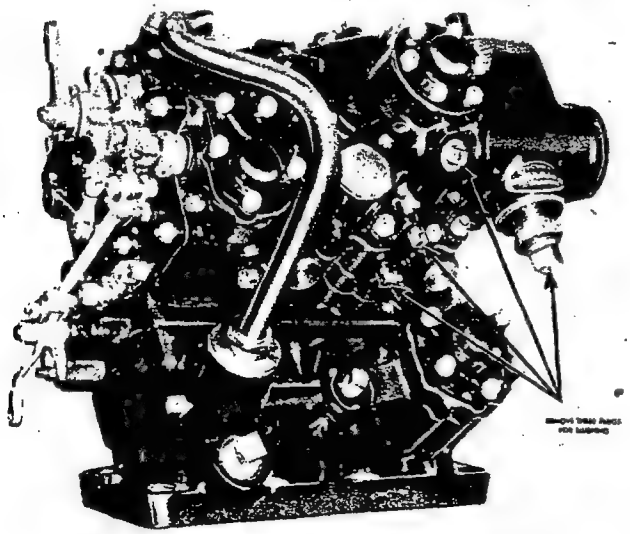

Figure 20—Drain Plugs (Bendix-Stromberg Carburetor)

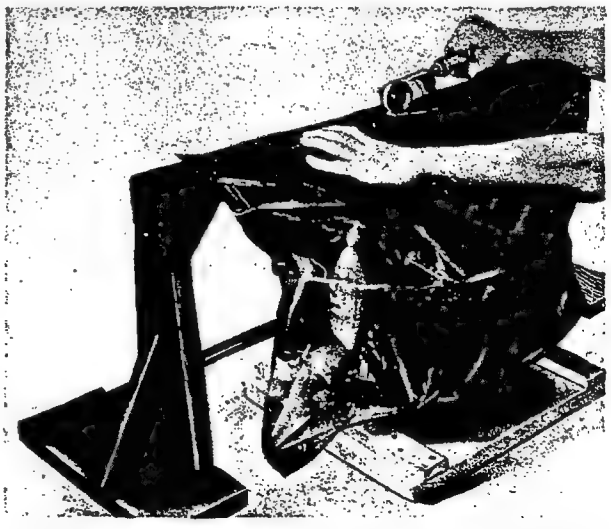

Figure 21—Sealing Carburetor in Plastic-film Envelope

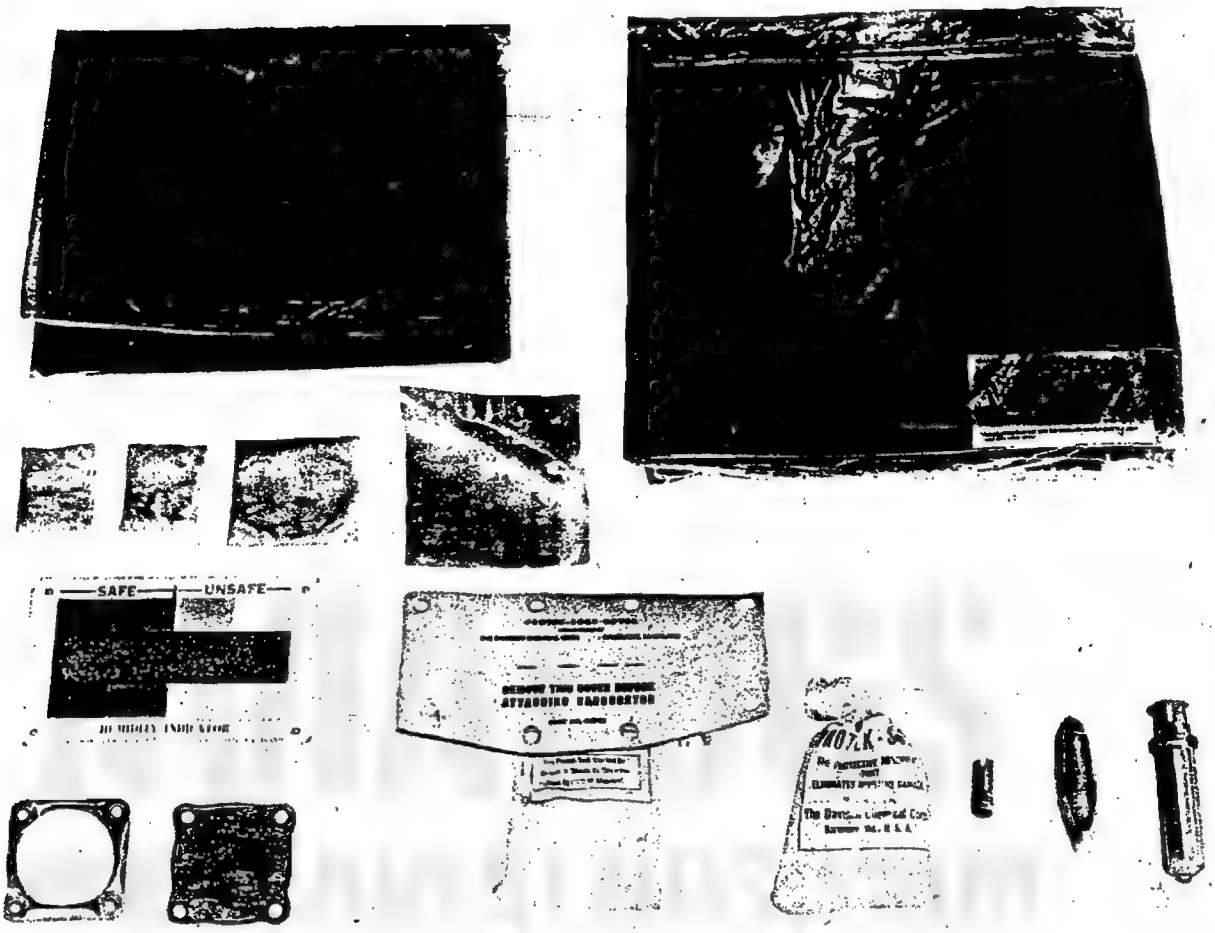

Figure 22—Engine Packing Equipment

p. Remove all the spark plugs and install the cylinder dehydrator plugs. Connect the ignition leads to the dehydrator plugs using spark plug terminal protectors and connections. See figure 22.

q. Remove the sump plug and install the crankcase dehydrator plug.

5. PREPARATION FOR STORAGE OF OPERABLE ENGINE TO REMAIN IN AIRCRAFT.

a. LESS THAN SEVEN DAYS.

(1) Operate the engine each day until normal oil-in operating temperature is reached. In cold climates operation of the engine may cease at 1/2 hour if normal oil-in operating temperature cannot be reached.

b. SEVEN TO THIRTY DAYS.

(1) Refer to paragraph 4, RUN-OUT AND SLUSHING PROCEDURE, and perform every operation except *g*.

(2) Cover all breathers and vents with moisture-resistant seals.

(3) Attach a one-pound bag of dehydrating agent in the carburetor air scoop and one in the exhaust system opening. Cover both openings with moisture-resistant seals and place a dehydrating agent warning card at each location.

c. MORE THAN 30 DAYS.

(1) Refer to paragraph 4, RUN-OUT AND

SLUSHING PROCEDURE, and perform every operation except *g*.

(2) Cover all breathers and vents with moisture-resistant seals.

(3) Disconnect and plug all oil-in and oil-out lines.

(4) Attach a one-pound bag of dehydrating agent in the carburetor air scoop and one in the exhaust system opening. Cover both openings with moisture-resistant seals and place a dehydrating agent warning card at each location.

(5) Cover the engine with the cover furnished by the aircraft manufacturer.

CAUTION

Inspect the dehydrator plugs weekly and replace them when a comparison of their color with the colors of a humidity indicator card indicates more than 20 percent humidity.

6. PREPARATION FOR STORAGE OF OPERABLE ENGINE TO BE REMOVED FROM AIRCRAFT.

a. MORE THAN THIRTY DAYS.

(1) Refer to paragraph 4, RUN-OUT AND SLUSHING PROCEDURE, and perform every operation. At some time during the procedure it will be necessary to remove the engine from the aircraft and place it in a disassembly stand. This may be done at the discretion of the operator. See figure 23.

(2) Cover all breathers and vents with moisture-resistant seals.

(3) Install the gasket and dehydrator bag assembly on the carburetor mounting pad and seal the induction passage tightly with a moisture-resistant seal.

(4) Install the oil tank vent sump in the oil tank vent connection on the supercharger rear housing cover. See figure 24. Lockwire the removed plug to any nearby location.

(5) Raise the engine from the disassembly stand.

(6) Lift the plastic-film envelope loosely over the supercharger rear housing and attach temporarily to the cylinders. Secure the mounting plate to the engine.

(7) Lower the engine and attach the mounting plate to the cradle of the shipping box.

(8) Coat the propeller shaft internally and externally with slushing mixture and AN-C-52, respectively. Wrap the shaft in a grease-proof, acid-free wrapper and secure with adhesive tape.

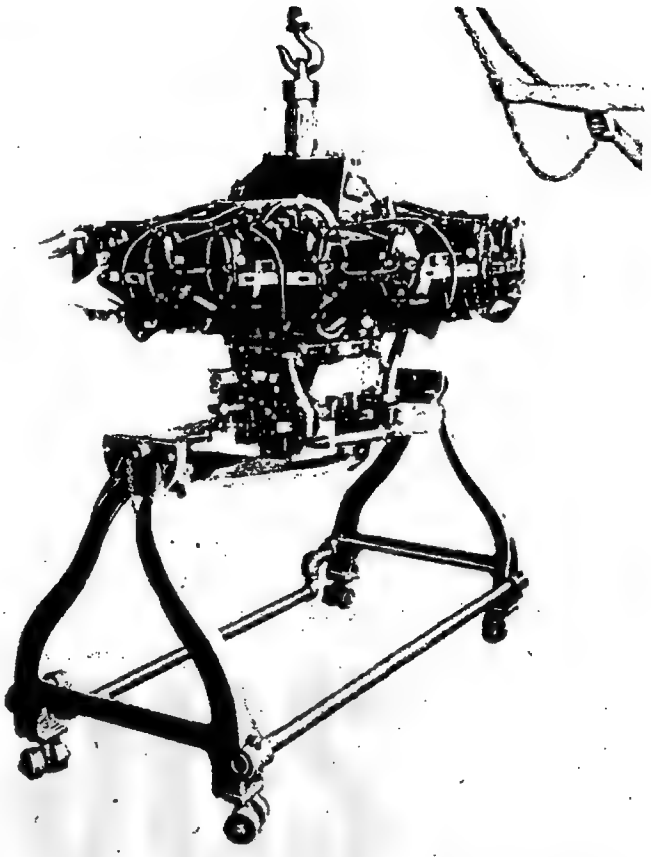

Figure 23—Mounting Engine on Disassembly Stand

(9) Attach to any location in and around the engine as many one-pound bags of dehydrating agent as there are cylinders. Fasten securely so that the bags will not rub or chafe the plastic-film envelope during shipment.

(10) Wrap heavy paper around the circumference of the engine at the cylinder heads and place the humidity indicator between the plastic-film envelope and the wrapping, so located as to be clearly visible from the inspection port in the shipping box cover.

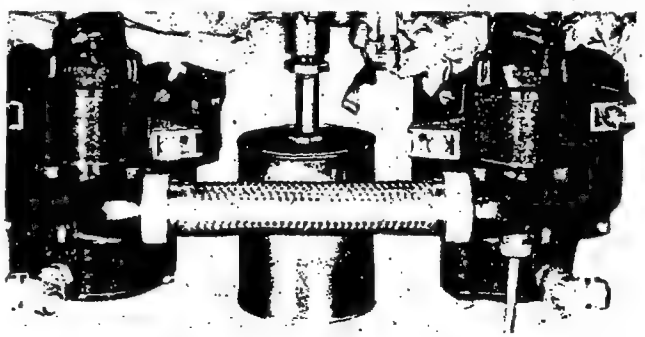

Figure 24—Location of Oil Tank Vent Sump

(11) Do NOT handle plastic-film at low temperatures as it cracks and breaks easily when cold. Just prior to using this material place it in a warm room to make it pliable. The best temperatures for working plastic-film are 21°C (70° F) or above. Roll the plastic-film envelope up over the propeller shaft. Make certain that the envelope is drawn around the engine very loosely so that it will not chafe. Heat-seal the envelope.

(12) TO HEAT-SEAL.—Bring the open edges of the envelope together over the top of the engine and, using the sealing iron (Tool No. 802924) at 163° to 177° C (325° to 350° F), seal them over a 1/2 inch wide area about 1/4 inch from the edge of the cut. A board covered with cardboard may be used to back up the material when the iron is run over it. While completing the sealing operation, slightly deflate the envelope and inspect it to see that no ruptures have occurred. A ruptured envelope must be resealed. Inspect the seam; if well vulcanized, it will be transparent through its length. A poor seam in which the iron was not the right temperature, or the surfaces were not pressed together will be cloudy or filmy. A poor seam should be repaired. Do not use too hot an iron as the envelope may be cut at the sides of the seam.

(13) After the sealing is finished, fold the excess material around the engine and secure it with tape so that there is no more than one thickness of envelope film between the humidity indicator card and the inspection port in the side of the shipping box. There will be sufficient material in the upper part of the envelope to cut off the sealed edge when the engine is removed. This excess material permits the envelope to be used five or six times. Whenever a failure occurs that will permit the entrance of moisture into the envelope, reseal as previously instructed, or with any moisture-resistant sealing tape.

(14) After treating all accessories which have been removed from the engine as instructed by their manufacturers, place each of them with a one-pound bag of dehydrating agent in individual plastic-film envelopes. Care must be taken not to break or chafe the envelope. Secure the accessories in the cradle of the shipping box.

(15) Shipping boxes that contain engines should be suitably protected from the elements and, where possible, should be stored indoors.

7. PREPARATION PRIOR TO DISASSEMBLY OF ENGINE INSTALLED IN AIRCRAFT.

a. OPERABLE ENGINE.—If the engine is to be disassembled within 48 hours, no run-out or slushing is necessary; otherwise:

(1) Refer to paragraph 4, RUN-OUT AND SLUSHING PROCEDURE, and perform every operation except *g*. At some time during this procedure it will be necessary to remove the engine from the aircraft and place it in a disassembly stand. This may be done at the discretion of the operator.

(2) Cover all breathers and vents with moisture-resistant seals.

(3) Attach a one-pound bag of dehydrating agent in the carburetor air scoop and one in the exhaust system opening, and cover both openings with moisture-resistant seals, and place a dehydrating warning card at each location.

b. INOPERABLE ENGINE.—No preliminary treatment is necessary if the engine is to be disassembled within 48 hours; otherwise, remove it from the aircraft, place it on a disassembly stand and perform as many of the following operations as possible.

(1) Place the engine front end down, remove a valve tappet guide and fill the crankcase front section with slushing mixture.

(2) Reinstall the guide, place the engine in flight position, and drain the sump.

(3) Remove the rocker box covers. Coat the rocker arm assemblies and covers with slushing mixture. Reinstall the covers.

(4) Remove the oil tank vent plugs from the supercharger rear housing and spray the gears with slushing mixture. If possible, rotate the crankshaft during this operation.

(5) Inject a few teaspoonfuls of hot, 79° to 107° C (175° to 225° F), slushing mixture through the spark plug holes into the combustion chambers.

(6) Remove the exhaust stacks, coat the exhaust valves and ports with slushing mixture, and cover them with moisture-resistant seals.

c. TREATMENT OF SUBMERGED ENGINE.—Do not raise the engine until preparations for its immediate treatment are completed. It is necessary that the steel parts be washed in unleaded gas and coated with slushing mixture, AN-C-52, or any other available compound, as soon as the engine is disassembled.

d. SLUSHING AND PACKING OF SPARE PARTS.—Spare parts to be packed for shipment or

storage should first be washed with a petroleum solvent, Federal Specification P-S-661, or kerosene, Federal Specification VV-K-211, and then slushed with a compound conforming to AN-C-52. Coat all surfaces, and allow to drain and dry for at least 10 minutes. Wrap with material conforming to AN-P-12. Store in a dry place. Parts to be shipped must be packed in suitable boxes with slings, blocks, or sufficient dunnage to prevent shifting. Specially constructed boxes are required for most large parts. Coat antifriction bearings with grease and wrap in grease-proof wrapper.

e. SHIPMENT OF STORED ENGINES BY AIR.—All engines to be shipped by air transport will be shipped on air transport cradles. Such shipment will necessitate the removal of the engine envelope and the dehydrator bags at the point of shipment. The engine will then be installed on the air transport cradles. Immediately upon receipt at its destination, the engine will be placed in a moisture-resistant envelope with dehydrator bags distributed around the cylinders. The propeller shaft should be coated with AN-C-52 or equivalent if this has not already been done. The only exception to this requirement will be engines which will be placed in service within seven days after arrival at the point of destination. In this case the crankcase and spark plug dehydrator plugs shall be inspected daily and be replaced when they indicate the relative humidity to be above 20 percent. Seals of replacement plugs shall not be removed until immediately before the plugs are screwed into their respective positions.

f. GENERAL PRECAUTIONS—HUMIDITY INDICATOR CARD.

(1) Inspect the engine humidity indicator card once every two to four weeks. See figure 25. Climatic conditions may necessitate a more frequent check. If the indicator shows an unsafe color, replace it and the dehydrator bags. At the same time, replace the crankcase and cylinder plugs if the color of their content denotes an unsafe condition. While making this inspection, repair any tears or ruptures that may be found in the transparent envelope.

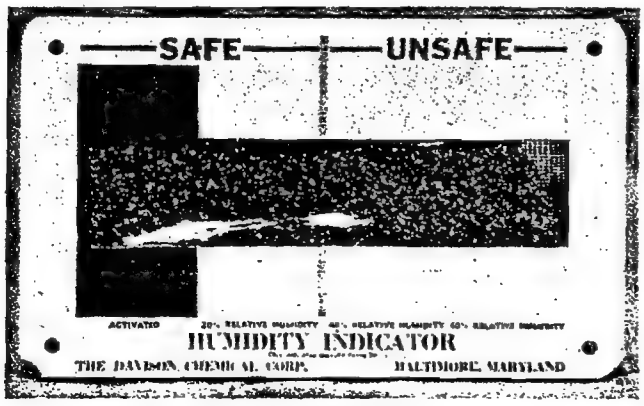

Figure 25—Humidity Indicator Chart

(2) If the dehydrating agent is exposed to the air for more than a few minutes it must be discarded. Do not break the dehydrator seals until just prior to installation in the engine.

g. REMOVAL OF ENGINE FROM SHIPPING BOX AND PREPARATION OF ENGINE FOR SERVICE.

(1) Break the seals and remove the four bolts from the metal straps on the shipping box.

(2) Attach a hoisting cable to the hooks on the metal straps and remove the shipping box cover. See figure 26.

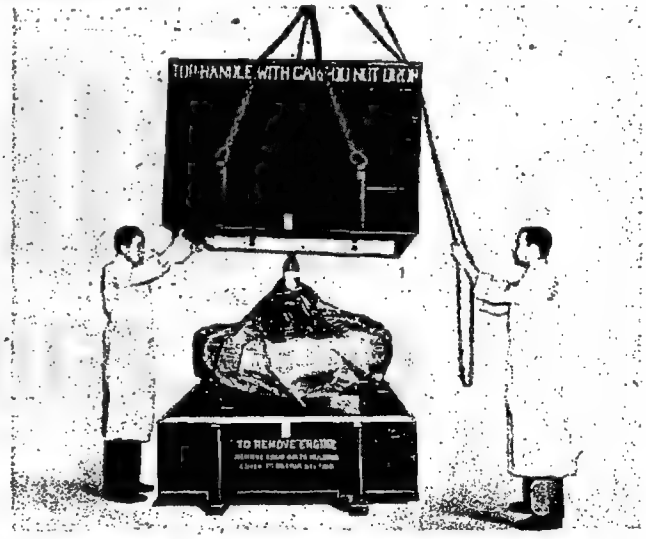

Figure 26—Raising or Lowering Shipping Box Cover

(3) Slit the plastic-film envelope along the top seam and roll the envelope down over itself to the engine mounting plate. Since the envelope may be used several times (as many as six), care should be taken in opening and removing it. If possible, the temperature at which plastic-film is handled should be 20° C (70° F) or higher.

(4) Remove all the dehydrator plugs and bags from in and around the cylinders and sump.

(5) Remove the thread protecting cap from the propeller shaft.

(6) Install a turning bar on the propeller shaft and reinstall the thread protecting cap.

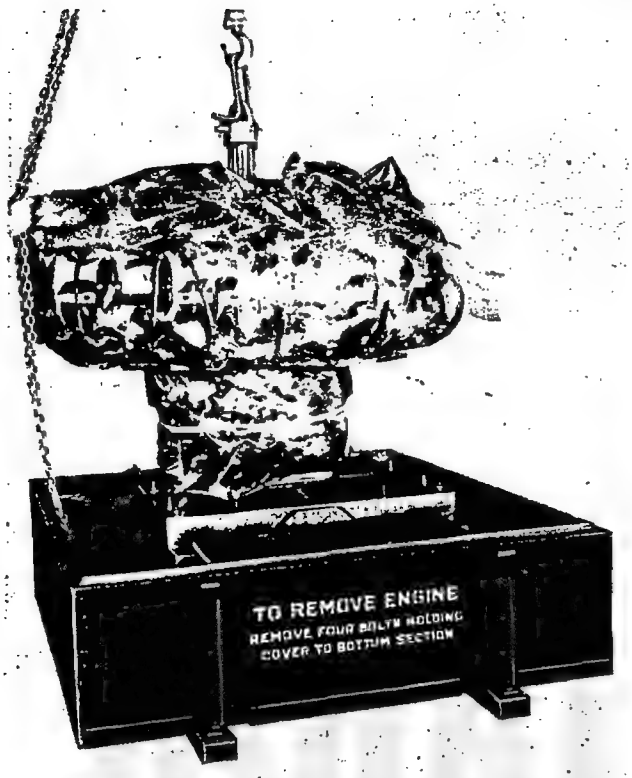

Figure 27—Removing Engine from Shipping Box

(7) Remove the thread protecting cap and turning bar and install the engine hoisting eye. Attach the hoist to the eye.

(8) Remove the nuts which secure the mounting plate to the cradle.

(9) Raise the engine and mounting plate from the shipping box. See figure 27.

(10) Remove the mounting plate and the plastic-film envelope from the engine. See figure 28.

(11) Remove the oil tank vent sump from the rear cover and install the plug which is wired nearby. Lockwire the plug.

(12) Secure the metal straps of the engine hoisting sling to the cowl attaching studs at the front and rear of the intake rocker boxes of cylinders No. 1 and 9, using eight lock washers and nuts. Insert the spreader bar between the two arms of the cradle assembly, and tighten the cable clamps before hoisting. Raise the engine to the flight position. See figure 29.

(13) Remove all the moisture-resistant seals from the exhaust ports and the vents.

(14) Remove, clean, inspect, and reinstall the oil filter and the magnetic sump plug.

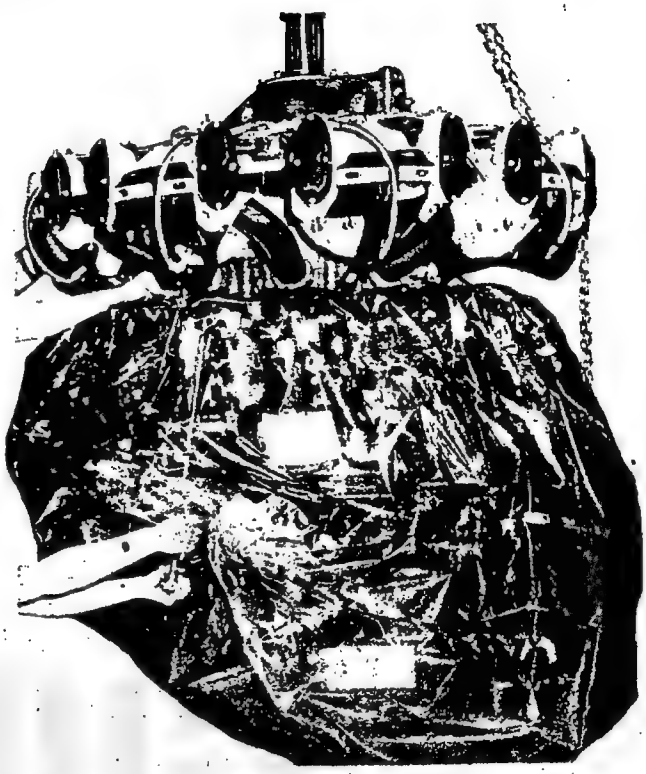

Figure 28—Removing Mounting Plate from Engine

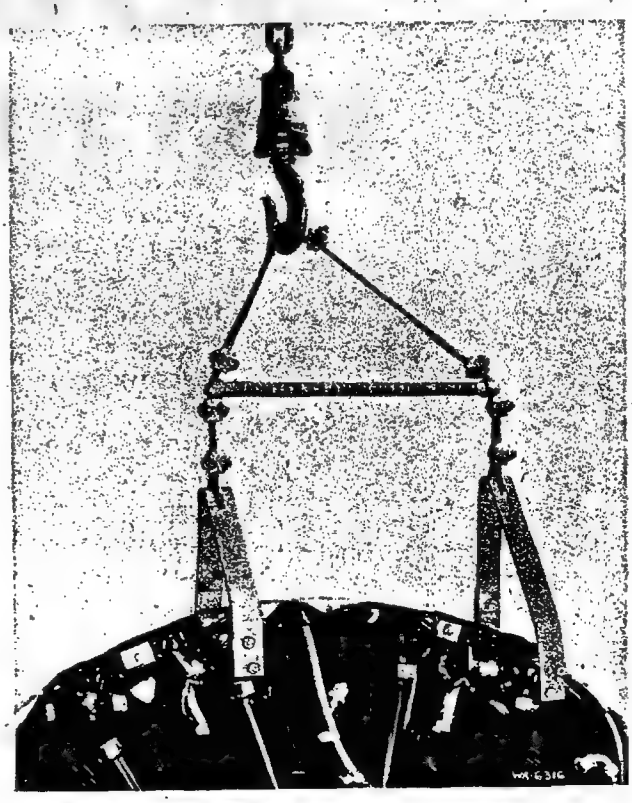

Figure 29—Location of Hoisting Sling

(15) Remove the supercharger drain valve, clean and reinstall.

(16) Reinstall all the engine parts which have been removed.

(17) Before installing treat the accessories as recommended by their manufacturer.

(18) Install the spark plugs.

(19) Pre-oil the engine with AN-VV-O-446, grade 1120.

(20) Operate the engine for fifteen minutes at 1000-1200 rpm. Remove and inspect the oil filter and the magnetic sump plug for foreign material. Drain the oil from the sump and reinstall the oil filter and the magnetic sump plug, then add enough fresh oil to replenish the oil supply before further operation.

SECTION IV

ENGINE TROUBLES AND SERVICE REPAIRS

1. GENERAL.

a. Determining the causes of engine troubles is at times rather involved due to the number of sources to which a given symptom may be attributed. The best method of trouble shooting is to consider the possible causes and then eliminate them one by one, starting with the most probable. The following chart lists possible troubles, their causes, and remedies for each.

b. When reporting failures, give the part name and number, its total time of service, the engine serial number, and the engine's total time of service. A detailed description of the failure should be included in the report.

Trouble	*Causes*	*Remedy*
FAILURE OF ENGINE TO START AND TO CONTINUE RUNNING	1. Lack of fuel	Repair any leaks in fuel system. Fill fuel tank. Clean dirty lines, strainers, or fuel cocks.
	2. Under-priming	During the procedures conducted prior to starting, it is essential that the engine be primed three or four strokes with the primer.
	3. Over-priming	Rotate crankshaft through a few revolutions with throttle full open and ignition switch off.
	4. Incorrect throttle setting	During starting procedures the throttle opening should be set at 1000 to 1200 rpm.
	5. Defective booster	See that booster is grounded to the engine. Check booster electric output.
	6. Defective spark plug ignition	Clean and dry terminal. If sleeve is cracked, replace with a good sleeve.
	7. Defective ignition wire	Replace any defective wires. Check wire with an electric tester.
	8. Dirty spark plugs	Clean plugs.
	9. Incorrect spark plug gap	Replace spark plugs with plugs set at proper gap. Use antiseize compound during installation.
	10. Defective battery	Replace with charged battery.
	11. Improper operation of magneto breaker points	Clean and adjust points. Test spark delivered by the magneto with an electric tester.
	12. Water in carburetor	Remove the drain plug at the base of the fuel control unit to drain off fuel and water.
	13. Incorrect valve clearance	Check the valve clearance. Refer to section VI of this handbook.
	14. Incorrect valve timing	Check the valve timing. Refer to section VI of this handbook.

Trouble	*Causes*	*Remedy*
FAILURE OF ENGINE TO START AND TO CONTINUE RUNNING	15. Internal failure	Examine the oil sump strainer. Trapped metal particles indicate internal trouble, and complete overhaul may be required.
FAILURE OF ENGINE TO IDLE PROPERLY	1. Incorrect carburetor idle adjustment	Check the idle adjustment of the carburetor.
	2. Leak in the induction system	*Tighten all connections and replace leaking parts.
	3. Low cylinder compression	Check compression with warm engine.
	4. Ignition system	Check entire ignition system.
LOW POWER AND UNEVEN RUNNING	1. Too rich a mixture indicated by blue flames, and, if excessively rich, white flames	Adjust the mixture strength to the specified fuel-air ratio by moving the mixture control manually.
	2. Too lean a mixture, indicated by overheating, backfiring, low fuel pressure, or low fuel supply	Adjust the mixture strength to the specified fuel-air ratio by moving the mixture control manually. Raise fuel pressure at fuel pump. Replenish fuel supply.
	3. Leaks in induction system	*Tighten all connections. Replace any leaking parts.
	4. Defective spark plugs	Clean plugs. Replace plugs if gap is incorrect. Use antiseize compound during installation. Test for proper sparking with an electric tester.
	5. Poor fuel	Replace with recommended fuel.
	6. Magneto breaker points not working properly	Test spark delivered by magneto with an electric tester. Clean and adjust points.
	7. Defective ignition wire	Check wire with an electric tester. Replace defective wires.
	8. Engine overheating	Refer to items 2, 3, and 5.
	9. Carburetor leakage	Replace carburetor if leakage is excessive.
	10. Defective spark plug terminal insulators	Replace insulators with good ones.
	11. Incorrect valve clearance	Check the valve clearance. Refer to section VI of this handbook.
	12. Incorrect valve timing	Check the valve timing. Refer to section VI of this handbook.
FAILURE OF ENGINE TO DEVELOP FULL POWER	1. Throttle lever out of adjustment	Readjust.
	2. Leak in the induction system	*Tighten all connections and replace leaking parts.
	3. Restriction in carburetor air scoop	Examine air scoop and remove restriction.
	4. Improper fuel	Drain fuel system and refill with proper grade.
	5. Faulty ignition	Check ignition system with tester and tighten connections.

Trouble	*Causes*	*Remedy*
ROUGH ENGINE	1. Cracked engine mount	Replace or repair mount.
	2. Defective bushings	Replace with new bushings.
	3. Governor control	Check operation.
	4. Propeller blade setting	Check that all blades are set equally.
	5. Malfunctioning engine	Check all previous engine troubles.
LOW OIL PRESSURE	1. Lack of priming	During the procedures conducted prior to starting, it is essential that the engine be primed three or four strokes with the primer.
	2. Leak in suction line	Replace any leaking parts.
	3. Dirty oil stainer	Remove and clean the strainer.
	4. Air lock or dirt in relief valve	Clean relief valve.
	5. Improper setting of relief valve	Adjust valve with engine running and oil at recommended temperature.
	6. High oil temperature	See High Oil Temperature in Trouble column.
	7. Oil foaming	Design of the oil tank may be faulty. This will necessitate replacing the tank.
OIL ACCUMULATION IN THE CRANKCASE	1. Lack of priming in scavenge pump	Prime the scavenge pump.
	2. High oil temperature	See High Oil Temperature in Trouble column.
	3. High oil pressure	Readjust pressure relief valve.
HIGH OIL TEMPERATURE	1. Insufficient oil cooling	Check cooler for clogging.
	2. Insufficient oil supply	Replenish oil supply.
	3. Low grade of oil	Replace with oil conforming to the proper specification.
	4. Improper operation of scavenge pump	Prime the scavenge pump.
	5. Failing or failed bearing	Examine sump for metal particles.
	6. Clogged oil lines, strainers, or coolers	Clean lines, strainers, or coolers.
	7. Improper venting of oil system	Check vents and vent lines for cleanliness and proper operation.
EXCESSIVE OIL CONSUMPTION	1. Low grade of oil	Replace with oil of the proper specification.
	2. Improper operation of scavenge pump	Prime the scavenge pump.
	3. Failing or failed bearing	Examine sump for metal particles.
	4. Worn piston rings	Replace piston rings.
	5. Incorrect installation of piston rings	Cylinder must be removed and new piston and ring assembly reinstalled.
COLD WEATHER DIFFICULTIES	1. Cold oil—if oil dilution is not used	Lagging, such as a layer of asbestos cord, shellacked, and then wrapped with friction tape should be provided on the external oil lines on the engine. Oil must be pre-heated to at least 50° C (125° F).

Trouble	*Causes*	*Remedy*
COLD WEATHER DIFFICULTIES	2. Inaccurate pressure readings	Gage lines should be filled with AN-O-6 instrument oil.
	3. Over-priming	Rotate crankshaft through a few revolutions with throttle full open and ignition switch off.
	4. Weak booster coil	An auxiliary hand booster may be necessary.
	5. Weak battery	A heavy duty battery should be used.

*** NOTE**

Do not tighten intake pipe packing nuts after ten hours of operation. It is permissible, however, to tighten the packing nuts, if necessary, within ten hours of operation after installing rubber packing because at this time the rubber packing is still soft and has not adhered tightly to the nut and the pipe. Leaking intake pipe packing is a fire hazard and a possible cause of improper mixture strength. Caution must be observed in following these recommendations.

SECTION V

SERVICE INSPECTION AND ASSOCIATED MAINTENANCE

1. GENERAL.

a. The work outlined in this section is a normal function of the operating organizations. It consists of the periodic inspection, cleaning, servicing, lubricating, adjusting, and such maintenance work as is associated with the routine inspection system.

b. The necessary tools for this work may be found listed in section VII.

	Daily	25-30 hours	50-60 hours	90-100 hours	200 hour	
1. Carburetor attachment		x		x		See that the carburetor is securely fastened.
2. Controls		x				Check all controls for proper functioning before flight: throttle, mixture control, cowl flap control, supercharger control, propeller governor control, carburetor air heater control. Lubricate all joints and bearings every 25 hours.
3. Carburetor fuel strainer	x					Remove and clean the carburetor fuel strainer.
4. Carburetor air filters	x					Service the carburetor air filters.
5. Carburetor air screen		At Overhaul				Unless experience indicates otherwise, clean the carburetor air screen at overhaul.
6. Fuel leakage	x					See that all fuel connections are tight. Replace any parts that cannot be tightened properly. Inspect the engine carefully for fuel leakage, frequently indicated by a dye stain from the fuel. The location of a leak may not always be where the stain is found. Replace or repair any parts which are causing fuel to leak.
7. Fuel system strainer	x					Remove and clean the strainer. Clean the fuel tank sediment bulb or sump.

	Daily	25-30 hours	50-60 hours	90-100 hours	200 hour	
8. Fuel tanks				x		Drain and clean the fuel tanks.
9. Oil change				x		Drain the oil system and refill with oil conforming to Specification AN-VV-O-446, Grade 1120. Change of oil is determined mainly by the conditions under which an engine is operated. Generally, oil should be changed every 100 hours. If a hopper tank is used, no change is necessary until overhaul or unless metal particles are present in the oil supply. However, if sandy operating conditions exist, it will be necessary to change oil more frequently.
10. Oil leakage	x					Check for oil leakage. If any leakage is indicated, locate the leak and repair. Leakage oil may appear some distance from the point of its origin. Check rocker box covers and all oil connections. See that the connections are tight. Replace any part that cannot be tightened properly.
11. Oil filter		x				Remove the oil filter, clean any sludge from the filter, and reinstall.
12. Oil sump strainer		x				Inspect the oil sump strainer for metal particles and analyze any particles which may be found. Any evidence of this kind should be investigated thoroughly to determine whether or not the engine should be disassembled. Wash and replace the strainer.
13. Oil cooler cores	x					Inspect the cores of the oil cooler to make sure that they are not plugged or coated with dirt. The cores should be kept clean for efficient operation.
14. Magnetic sump plug		x				Inspect the magnetic plug for metal particles. Refer to item No. 12 for analysis of metal particles.
15. Spark plugs				x		Change plugs at 100 hours. If at this time the gap exceeds .020 inch the plugs should be changed every 50 hours. If engine roughness is attributable to the spark plugs or punctured ignition cable trouble is experienced prior to 100 hours, the plugs should be changed every 50 hours.
16. Spark plug terminals	x					See that the spark plug terminals are secure. The terminal nut should be snug, but care must be taken not to damage the nut by overtightening.
17. Magneto lubricating felt				x		No lubrication is necessary for Bosch magnetos until overhaul. Scintilla and Edison Splitdorf magnetos should be inspected at 100 hours. CAUTION: More harm can be done by over-oiling the felt than by not having sufficient oil. The oil should appear on the felt only when the felt is squeezed between the fingers. Add one or two drops of oil, if necessary, to obtain this condition.

	Daily	25-30 hours	50-60 hours	90-100 hours	200 hour	
18. Cylinder fins	x					Inspect the cylinder fins to make sure that they are not coated with dirt. Check for any cracked fins. The location and extent of the crack will determine whether the cylinder must be replaced or the crack may be removed by profiling. An engine with a cracked cylinder fin should not be operated until the condition has been corrected.
19. Air deflectors			x			See that the air deflectors are tight and that the proper clearances exist between the deflector and the cylinder fins.
20. Nuts and cap screws	x	x				Inspect all accessible nuts and cap screws daily to insure that they are tight and properly locked. Inspect all cylinder lock wiring every 25 hours. Unless the cylinder lock wiring is broken or the cylinder hold-down cap screws are loose, these nuts need not be tightened except at overhaul. CAUTION: If the occasion arises, always tighten all the cylinder hold-down cap screws for any one cylinder.
21. Breather screen				x		Remove and clean the breather screen in a wash gasoline.
22. Engine exterior					x	Clean the exterior of the engine thoroughly. If any parts are removed from the engine prior to 200 hours, the engine should be cleaned before removing part.
23. Compression					x	Check compression of each cylinder removing one spark plug from all the cylinders except the one being tested. If available, use a pressure gage in place of one of the spark plugs in the cylinder being tested. Pressure should register nearly equal for all cylinders. If such a gage is not available, a general indication of the compression may be obtained by leaving both spark plugs in the cylinder being tested and rotating the engine with the propeller by hand. Resistance to the turning of the propeller by hand should be about the same for all cylinders.
24. Valve clearances		x			x	Remove the rocker box covers and check the valve rocker clearances. Reset any clearances which are not within the specifications. The engine should be cold when setting or checking these clearances. Check for broken valve springs every time the rocker box cover is removed. Valve clearances should be checked at the end of the first 25 hours after installation and again at the 200-hour inspection period.
25. Intake pipes					x	Check the intake pipe packing nuts and cap screws. Do not tighten intake pipe packing nuts at this inspection since such tightening will break the adhesive seal which cannot be formed again by further tightening. If the packing has been in operation 25 hours or less it may be tightened, however, since it is still soft and will not have adhered to the nut. If the packing has been in operation more than 25 hours and a leak is evident, the packing must be replaced. Leaking intake pipe

	Daily	25-30 hours	50-60 hours	90-100 hours	200 hour	
						packing is a fire hazard and a possible cause of improper fuel-air ratio, and it is therefore recommended that the utmost caution be observed in following these recommendations.
26. Exhaust system	x				x	Check the exhaust pipe or exhaust manifold daily for cracks or warping. Check for tightness at the 200-hour inspection unless evidences of burning are indicated during daily inspection. Care must be taken to tighten all exhaust flange stud attaching nuts equally to insure that no distortion of the part takes place. Exhaust leakage at this location caused by flange distortion or insecure fastening may result in the burning of the exhaust port. WARNING: Care should be exercised to avoid pulling the exhaust flange attaching nuts too tightly and stripping the studs from the exhaust ports.

SECTION VI
ADJUSTMENT, REPLACEMENT, AND MINOR REPAIRS

1. GENERAL.

a. The work outlined in this section can be performed without the facilities usually available at major overhaul stations.

b. The object of the instructions in this section is to establish the correct procedure for the replacement of such component parts of the engines as cylinders, carburetors, magnetos, and starters.

c. The overhaul instructions are outside the scope of this handbook.

2. SPARK PLUGS.

a. It should be noted that the thickness of the solid copper gaskets or washer-type thermocouples used with these engines must conform to the following limits:

b. Maximum—.095 inch, Minimum—.068 inch. This is to obtain the maximum efficiency of the spark plugs, less danger of overheating and detonation, and ease of removal.

3. CYLINDER AIR DEFLECTORS.

a. To accomplish minor repair work on the cylinder assemblies it is frequently necessary to remove cylinder head or cylinder barrel air deflectors.

b. REMOVAL OF CYLINDER HEAD AIR DEFLECTORS.—If not previously removed, remove the rear spark plug ignition lead from the channel in the deflector. Break the lock wire and remove the fillister head screw which secures the attaching flange at the cylinder intake port. Break the lock wire from the two fillister head screws at the top of the deflector and remove the screws. The cross member is slotted to permit easy access with a screwdriver.

c. INSTALLATION OF CYLINDER HEAD AIR DEFLECTORS.

(1) Place the air deflector in its approximate position on the cylinder head. Loosely install the three fillister head screws. Insure that lock washers are installed under each of the screws and tighten down each screw evenly. Lockwire each of the screws securely. If the cross members were disassembled, new elastic stop nuts should be used during assembly.

(2) Place the rubber-covered ignition lead to the rear spark plug in its channel section in the deflector. Press the lead down into the channel so that it is below the contour of the cross members of the deflector.

d. REMOVAL OF CYLINDER BARREL AIR DEFLECTORS.

(1) To remove the cylinder barrel air deflectors of any of the upper five cylinders, it will first be necessary to remove the priming system tubes (if five-point system is used) in accordance with the instructions outlined in paragraph 4 of this section.

(2) Remove the intake pipes, using the procedure described in paragraph 5 of this section.

(3) Remove the elastic stop nut and washer from the through bolt securing the cylinder barrel deflector and the barrel clamp. Remove the elastic stop nut and washer from the stud holding the deflector at the rocker box cover extension locations. The rubber grommet and plate should be temporarily bolted to the deflector stud to prevent loss. Remove the cylinder barrel air deflector from the rear. It will be unnecessary to remove the rubber packing unless replacement is required.

(4) To remove the cylinder barrel air deflector from the sump section, remove the nut, retaining plate, and grommet securing the deflector to the rocker box cover extensions. Break the lock wire and remove the two cap screws securing the deflector to each arm of the sump. Withdraw the deflector to the rear.

e. INSTALLATION OF CYLINDER BARREL AIR DEFLECTORS.

(1) Place the air deflector in its approximate position between the cylinders.

(2) Place the air deflector clamp so that the edges of the channel-shaped clamp fit into the fifth and eleventh fin space, counting the space between the first and second fin at the crankcase end of the cylinder as No. 1. Loosely install the through bolt through the deflector, spacer, and clamp. Install a new elastic stop nut but do not tighten at this time. Line up the deflector so that the stud protrudes through the space between the two rocker box cover extensions. Install the grommet and retaining plate, secure with a new elastic stop nut. Tighten the air deflector clamp at the base of the air deflector.

(3) To install the air deflector at the sump location, place the deflector in its approximate position. Loosely install the two cap screws and washers securing the deflector to the two arms of the sump. Line up the stud with the space between the two rocker box cover extensions, install the rubber grommet and retaining plate, and secure the assembly with a new elastic stop nut. Tighten the cap screws in the sump arms and lockwire securely.

4. PRIMING SYSTEMS.

a. REMOVAL OF FIVE-POINT PRIMING SYSTEM.—Detach the supply line from the distributor. Unscrew the priming tube union nuts from the fitting on the intake ports of the five upper cylinders and at the distributor nipples. See figure 30. If the same tubes are to be installed, tag, or otherwise mark, each priming tube to indicate to which cylinder it is attached. Remove the nuts, washers, and bolts securing the priming tube clamps to the intake pipes. Spread open the clamps and remove the priming system tubes. It will be unnecessary to remove the distributor from the No. 1 cylinder intake pipe if this unit does not require replacement. Exercise extreme care in removing the priming tubes to prevent their bending. A bent tube will present great difficulty in installation and may restrict the flow of the priming charge in the tube.

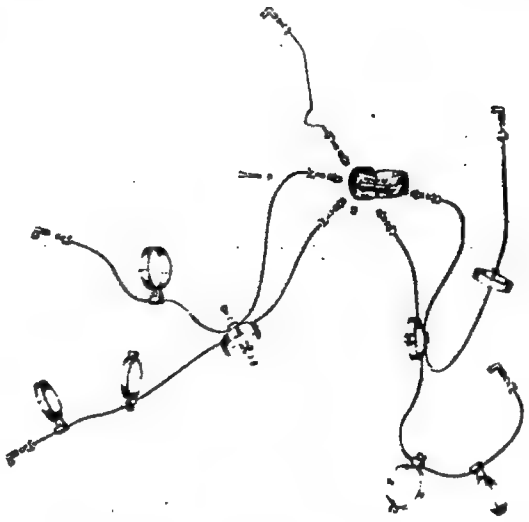

Figure 30—Five-Point Priming

b. INSTALLATION OF FIVE-POINT PRIMING SYSTEM.—If removed, attach the distributor to the clamp and place the clamp on the No. 1 cylinder intake pipe facing the rear, and at a location 8 inches from the center of the distributor to intake pipe packing nut. Do not tighten the clamp at this time. Place each priming tube in its approximate location and by placing No. 3 priming tube in one of the upper locations, slip the clamps over the intake pipe, install the nuts and bolts, but do not tighten. Screw on the union nuts at the intake ports and the distributor. Tighten each union nut at the intake port and distributor location, have the lower priming tube clamp set so as to have the tightening screw on the forward side. (See figure 31.) Tighten all clamp nuts.

c. TWO-POINT PRIMING.—If it is necessary to remove the priming system, or to separate the carburetor and carburetor adapter on engines incorporating the two-point priming system, remove the priming lines and their attaching brackets, the priming nozzles, priming distributor, all hoses and tubing to the distributor from the carburetor and solenoid, the solenoid, and the electrical junction box and conduits. See figure

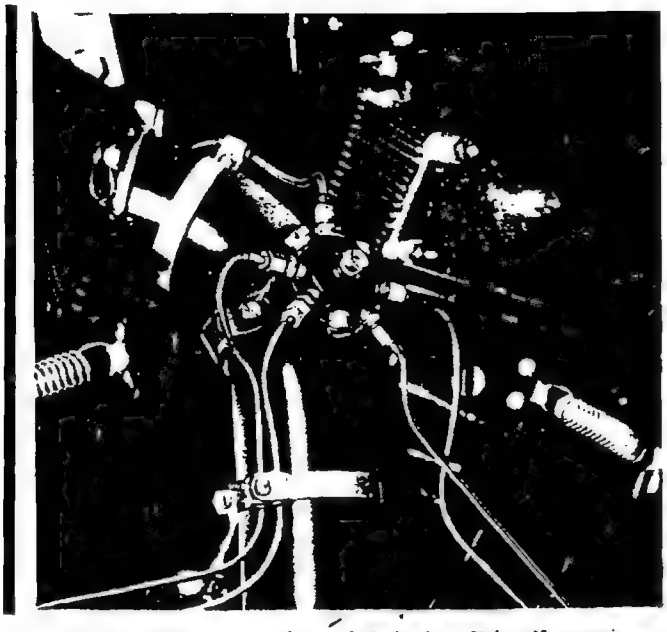

Figure 31—Location of Priming Distributor

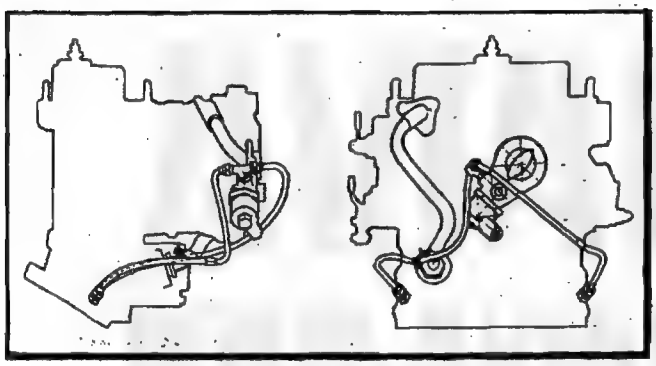

Figure 32—Two-Point Priming

32. Tag all priming lines, hoses, and tubing to insure that they will be installed in their original positions on the engine when the engine is reassembled.

d. ONE-POINT PRIMING.—Remove the cone, nipple, and union nut with the primer line from the primer connection hole at the rear parting surface of the supercharger front housing. Reassemble by installing the nipple in the front housing. The union nut must be installed on the primer line and the cone must be brazed to the end of the line. The nut is used to attach the line to the nipple.

5. INTAKE PIPES.

a. REMOVAL.

(1) The intake pipes of the upper five cylinders support the five-point priming system. When removing any of these intake pipes, it will first be necessary to remove the priming system tubes as described in paragraph 4 of this section.

(2) Loosen the packing nut at the crankcase end of the intake pipe. This may be done with the special crowfoot-type wrench (Tool No. 84258) which fits the castellations on the nut snugly. See figure 33.

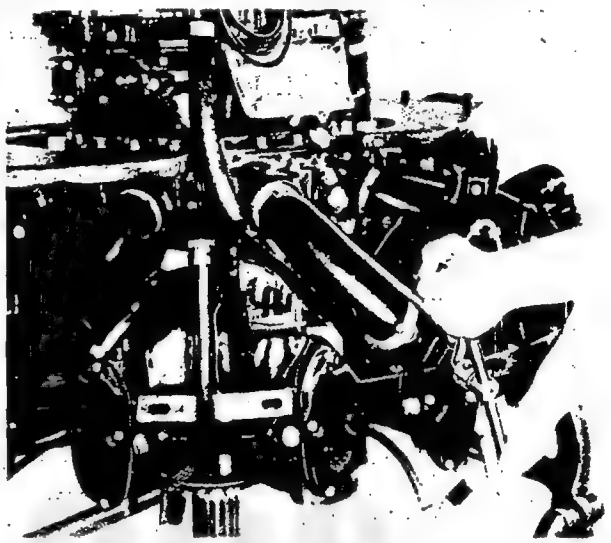

Figure 33—Loosening Intake Pipe Packing Nut

(3) Remove the three cap screws at the flanged end of the intake pipe. Remove the shakeproof lock washers and pull the flange back from the intake port. Discard the gasket.

(4) Withdraw the intake pipe from the supercharger front housing. Remove the packing nut and packing. Discard the packing.

(5) Install a cover (Tool No. 800909) over the intake port of each cylinder. See figure 34. Install a

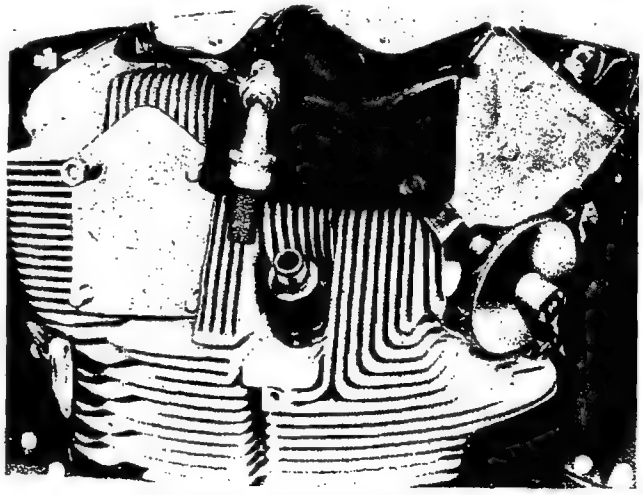

Figure 34—Location of Intake and Exhaust Covers

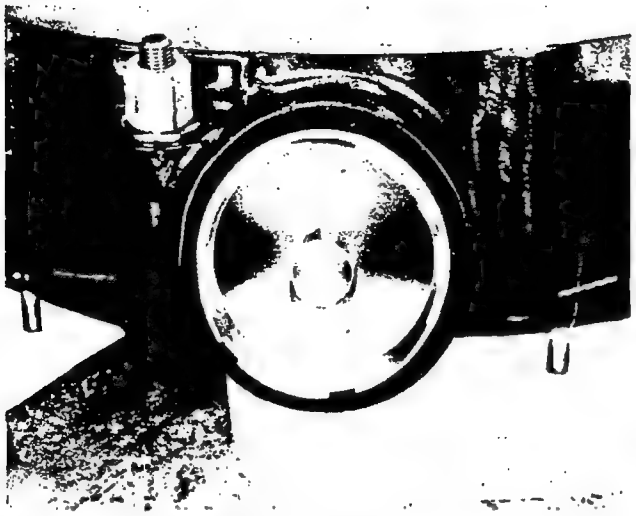

Figure 35—Intake Pipe Packing Nut Cover Location

cover (Tool No. 800907) in all intake pipe packing nuts in the supercharger. See figures 35.

b. INSTALLATION.

(1) Install a new packing ring in each intake port in the supercharger front housing, and loosely install the nine packing nuts.

(2) Install a new packing ring under the intake pipe attaching flange at the cylinder end. Coat the crankcase end of the intake pipe with clean engine lubricating oil and insert into the supercharger front housing.

(3) Install a new gasket at the intake pipe attaching flange and the intake port parting surface and install the three cap screws making sure a shakeproof washer is installed under the head of each cap screw. Tighten each cap screw evenly, and lockwire securely. Tighten the packing nut at the crankcase end of the intake pipe using the crowfoot-type wrench (Tool No. 84258) and handle (Tool No. 81403).

6. EXTERNAL HYDRO-OIL LINE.

a. REMOVAL.

(1) Loosen the nut which secures the front tube of the external hydro-oil line to the crankcase front section. See figure 36 for the oil line connection to crankcase front section.

(2) Loosen the coupling attaching nut.

(3) Loosen the rear cover attaching nut to which the rear bracket has been attached. Remove the bracket.

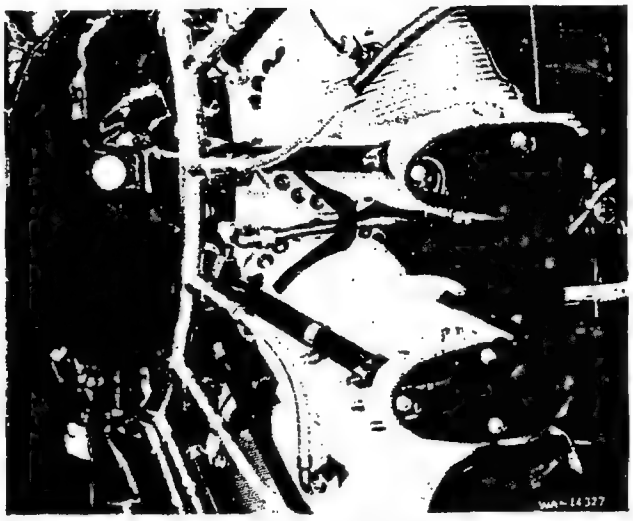

Figure 36—External Hydro-oil Line Connection and Front Tube (R-1820-97)

(4) Loosen and remove the castellated nuts which secure the flange over the two studs on the rear cover. Remove the flange and gasket.

(5) Remove the rear oil tube and, after removing clamp and bracket on the front tube assembly, remove the front oil tube. Cover the elbow in the crankcase front section and the connection to the left of the rear cover starter pad to prevent articles from falling inside these openings.

b. INSTALLATION.

(1) Remove the covers from the crankcase front section and the connection to the left of the rear cover starter pad location.

(2) Assemble the clamp and bracket on the front tube assembly.

(3) Insert the front end of the tube from the rear of the engine under No. 7 intake pipe and under intercylinder air deflector between cylinders No. 7 and 8. Screw the front connection nut onto the elbow installed on the crankcase front section. Do not tighten at this time.

(4) Attach the front tube to the supercharger rear housing to front housing attaching flange, using clamp and bracket.

(5) Assemble clamp and bracket on the rear tube assembly.

(6) Place a gasket over the two studs at the oil tube connection location on the rear cover. Install a flange over the two studs and secure with castellated nuts.

(7) Secure the front and rear tubes together by tightening the coupling attaching nut.

(8) Attach the rear bracket to the rear cover by removing one of the rear cover attaching nuts in a suitable location, placing the bracket over the stud and reinstalling the cover attaching nut.

(9) Securely tighten connections, bracket, clamp screws, and nuts.

7. EXTERNAL OIL SCAVENGE LINE.

a. Loosen the clamps and push back the hose connections which secure the external oil scavenge line to the sump and to the inlet to the oil pump. Loosen the clamp which secures the line to the intake push rod housing of cylinder No. 6 and loosen the clamp and extension which secures the rear external oil scavenge line to the supercharger rear housing parting flange. Separate the two lines by loosening the clamps and the hose. Pull the rear external oil scavenge line through the drilled passage in the fire wall.

b. ASSEMBLY.

(1) Install the front external oil scavenge line, secure it to the sump adapter with the short hose connection and two clamps. Attach the front scavenge line to the intake push rod housing of cylinder No. 6 with a clamp, nuts, and bolts.

(2) Insert the rear external oil scavenge line through the drilled passage in the fire wall.

(3) Using two clamps and hose, attach the rear external oil scavenge line to the front scavenge line. Clamp the rear tube, using the clamps and extension to the nearest stud securing the supercharger rear housing to the supercharger front housing. The extension is bolted to the clamp with a bolt, washer, and nut. Assemble the rear external oil scavenge line, securing it to the inlet of the pump with one short hose connection and two clamps.

8. OIL SUMP.

a. REMOVAL.

(1) If not already removed, remove the No. 5 cylinder intake pipe as outlined in paragraph 5 of this section. It will also be necessary to remove the cylinder air deflectors as described in paragraph 3 of this section, if they are not already removed.

(2) Break the lock wire and remove the screened sump plug, using wrench (Tool No. 82058). Remove the magnetic drain plug from the bottom of the sump. Drain the oil into a clean receptacle, strain and examine carefully for foreign material. Reinstall the plugs loosely in their proper locations to prevent their loss.

(3) Remove the three palnuts, nuts, and washers securing the front attaching flange to the crankcase front section.

(4) Support the sump and remove the two palnuts, nuts, and washers from each arm of the sump which secure it to the supercharger front housing. Withdraw the sump.

b. INSTALLATION.

(1) Remove the screened and magnetic plugs from the bottom of the sump.

(2) Install new gaskets at the mounting flange locations. Make sure that the oil holes line up perfectly with the holes in the sump.

(3) Attach the sump in its proper position, using washers and nuts. Tighten all nuts evenly to the proper tightening torque as listed in the Table of Torques in the back of this manual. Install palnuts on each of the studs and tighten one-quarter turn beyond finger tight.

(4) Reinstall the screened and magnetic drain plugs using new gaskets under each. Lockwire the plugs securely together.

(5) Reinstall the air deflectors and intake pipes as directed in paragraphs 3 and 5, respectively, of this section.

9. PUSH RODS AND VALVE TAPPETS.

a. REMOVAL AND DISASSEMBLY.

(1) The following procedure is given for cases in which it is desired to remove a push rod without removing the rocker arm hub bolt or disturbing the torque setting which has previously been applied to the rocker bolt nut. See figure 37.

(a) Remove the clips securing the ignition leads of the manifold to the push rod housings. It will be unnecessary to remove the clips from the leads.

(b) Loosen the two hose connection clamps at the crankcase end of the push rod housing and the single hose clamp at the cylinder end of the housing. Slide the crankcase end hose connection along the push rod housing until the bead on the end of the housing is visible.

(c) Using speed wrench (Tool No. 84566), remove the nuts from the four rocker box cover attach-

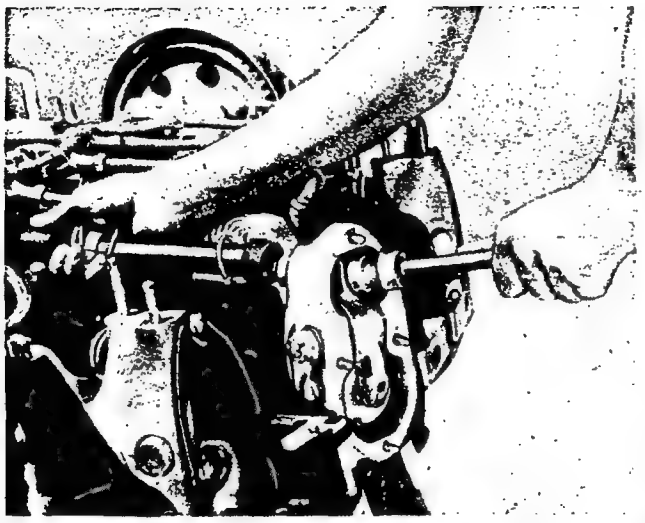

Figure 37—Removing Push Rod

ing studs of the rocker box from which the push rod is being removed and remove the cover. Discard the gasket. Magnet (Tool No. 84770) is recommended for rapid removal of the lock washers and plain washers from the rocker box cover attaching studs. Loosen the adjusting screw lock screw in the rocker arm and screw the adjusting screw all the way out to its stop. See figure 38. Screw the push rod removing tool (Tool

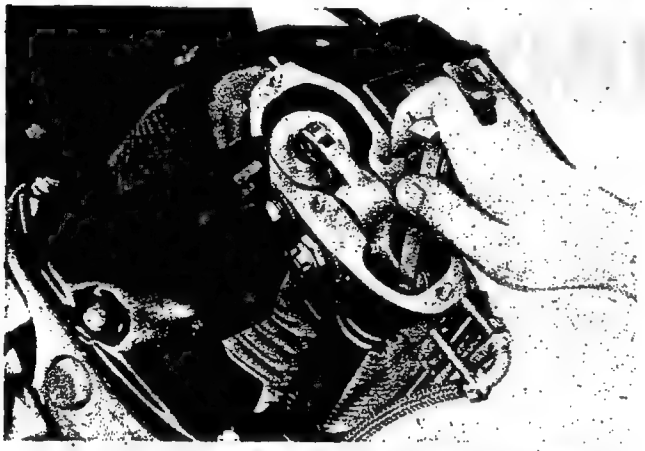

Figure 38—Loosening or Tightening Adjusting Screw Lock Screw

No. 82703) on the extended threads of the valve clearance adjusting screw and insert the handle to serve as a lever and compress the valve springs. The push rod, housing, and hose connection may be removed as a unit through the slot in the tappet guide.

(2) If the special push rod removing tool is not available, it will be necessary to remove the rocker arm before the push rod can be withdrawn. Remove the rocker box cover as previously described. Remove the cotter pin from the rocker bolt nut and remove the nut. Turn the crankshaft, using the turning tool (Tool No. 82284), which is installed on the propeller shaft splines, and two handles (Tool No. 80292) so that the valve is seated and a clearance exists between the rocker roller and the valve stem. Push or drive out the rocker bolt, being careful not to damage the bolt threads, and remove the spherical seat washer from each end. See figure 39. Lift out the push rod

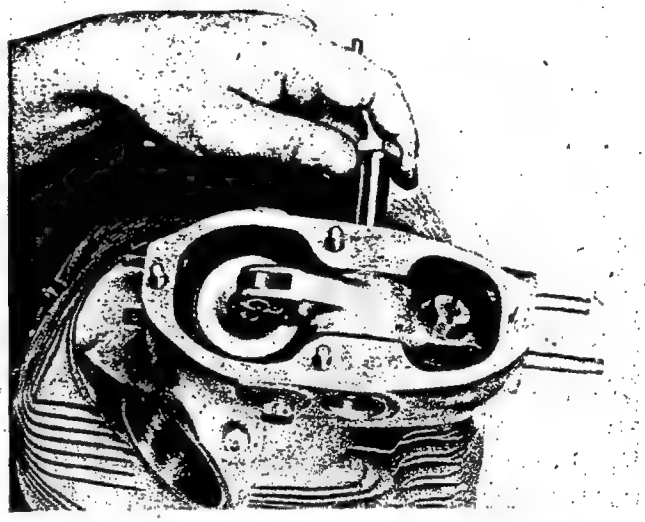

Figure 39—Removing or Installing Rocker Arm Hub Bolt

and remove the housing by loosening the clamps and sliding the crankcase end connections along the housings.

(3) Remove the loose-fitting valve tappet ball socket and mating spring, turning the crankshaft, if necessary, to push the tappet into reach. Remove the palnuts, nuts, and washers from the two tappet guide attaching studs and withdraw the tappet and guide assembly from the crankcase front section. If the guide cannot be removed by hand, attach the tappet guide puller. See figure 40. This consists of a rod which clamps to the bead on the tappet guide. A weight slides along the rod to provide the necessary inertia for removing the guide. Remove the gasket under the guide flange.

(4) The tappet and guide assembly may be separated by inserting the hooked end of the valve tappet circlet removing tool under the retaining circlet to effect its removal. *Do not attempt to make the circlet jump out of its groove by striking the hollow end of*

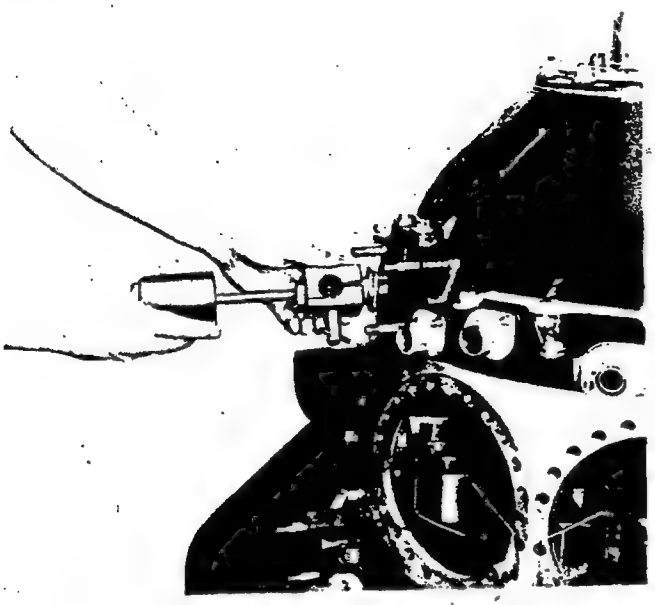

Figure 40—Removing Tight Fitting Valve Tappet Guide

the tappet with a drift. Care should be taken to avoid loss of any of the parts during this operation as the floating tappet roller, bushing, and pin are exposed when the retaining circlet is removed. The tappet may be separated from its guide and complete disassembly of the roller and bushing effected by pushing the floating pin out of the slotted end of the tappet.

b. ASSEMBLY AND INSTALLATION.

(1) Place the tappet roller equipped with its floating bronze supporting bushing in the slotted end of the tappet and insert the floating pin. Slide the tappet and roller into the tappet guide and install the retaining circlet with the installing tool. See figures 41 and 42. Install a new gasket under the tappet guide flange and insert in the crankcase front section. Install a plain washer, nut, and palnut on each of the two attaching studs. Insert the coiled spring and valve

Figure 41—Placing Circlet on Installing Tool

Figure 42—Installing Circlet

tappet ball socket into the hollow tappet. Insure that all parts are thorouhgly coated with engine oil before assembly.

(2) Install a new short hose connection and one clamp on the rocker box end of the push rod housing. This end of the push rod housing may be identified by the location of the beading which is approximately 3/8 inch from the end. Install new long hose connection and two clamps on the crankcase end of the housing. The beading at this end of the housing is directly on the end. The installation of the hose connections will be facilitated if a thin coat of engine oil is placed on the housing.

(3) When assembling a push rod assembly, which was withdrawn without removing the rocker arm, proceed as follows:

(a) Oil the push rod ball end and insert the push rod in its housing, having the hose connection at the crankcase end flush with the bead on the housing.

(b) Compress the valve spring and rocker arm, using Tool No. 82703 described in the removal instructions. With the valve spring compressed, slide the push rod housing hose connection into position at the rocker box and push the crankcase end of the push rod through the slot in the tappet guide.

(c) Remove the valve spring compressing tool from the rocker arm. Push the push rod housing all the way into its rocker box hose connection and tighten the hose clamp. Slide the crankcase end hose connections over the tappet guide and tighten both hose clamps.

(d) Set the valve clearance in accordance with the instructions in paragraph 10 of this section.

(4) If the rocker arm was removed when the push rod was removed, the following additional instructions are applicable:

(a) With the hose connections and clamps assembled on the push rod housing, install the housing on the engine, pushing it all the way into its rocker arm hose connection while tightening the clamp. Slide the crankcase end hose connection over the tappet guide and tighten both clamps.

(b) Oil the push rod ball ends with clean engine lubricating oil and insert in the push rod housing through the rocker box. Install the rocker arm and insert the rocker bolt through its hub. Insure that the spherical seat washers are installed at each end of the through bolt. The bolt should be installed with the head facing the cylinder head center line.

(c) Before tightening the castellated nut on the rocker bolt, check the end clearance between the bearing inner race and the rocker box. See figure 43. If it is over the limit (.005T-.015L inch) remove the bolt and install a shim to take up the excess.

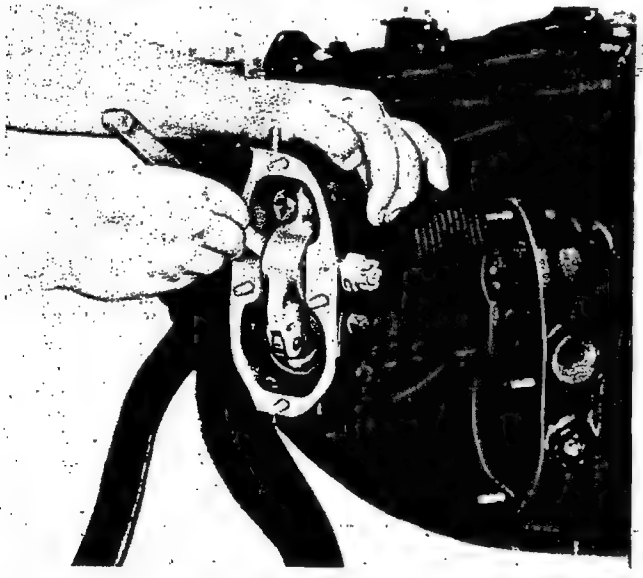

Figure 43—Checking Rocker Arm Bearing Side Clearance

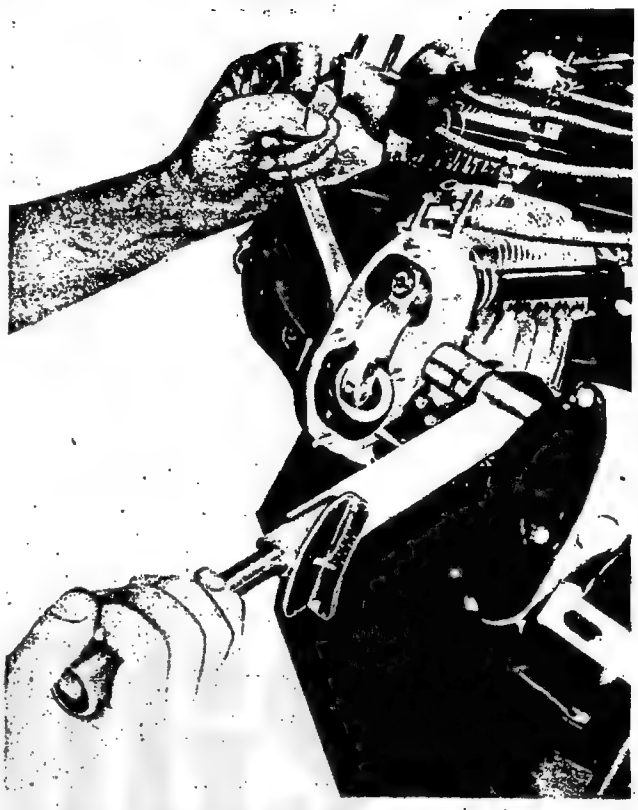

Figure 44—Tightening Rocker Arm Hub Bolt

(d) Tighten the rocker bolt nut to the torque value using the torque indicating handle. See figure 44. If the hole in the bolt cannot be lined up when using the correct torque value, remove the nut and install a new washer. Repeat the above procedure. Install a new cotter pin of the correct size.

(e) Set the valve tappet clearance in accordance with the instructions outlined in paragraph 10 of this section.

(f) Fill the rocker boxes with clean engine lubricating oil and install a new gasket over the rocker box cover attaching studs. Install the cover and secure with plain washers, shakeproof washers, and nuts.

(g) Reinstall the ignition harness retaining clips on the push rod housings, if removed.

10. CYLINDERS, VALVES, PISTONS.

a. CYLINDER REMOVAL.

(1) Remove the four exhaust stack attaching nuts and lock washers. It may be found necessary to remove whole or part of the exhaust manifold in order to facilitate the removal of the cylinders.

(2) Disconnect the ignition leads to the front and rear spark plug terminals and remove the air deflectors in accordance with the instructions given in paragraph 3 of this section.

(3) Remove the intake pipe following the instructions in paragraph 5 of this section. It may be necessary to remove the intake pipe of the adjacent cylinder for accessibility.

(4) Remove the rocker box covers, rocker arms, push rods and housings according to paragraph 9 of this section.

(5) To remove cylinders adjacent to the two main front to rear ignition shielding conduits, it will be necessary to remove all the attaching clamps, and the knurled nuts on the shield assembly. Otherwise the cylinder hold-down cap screws will not be accessible.

(6) To remove the cylinders adjacent to the oil sump, the oil sump must first be removed following the instructions outlined in paragraph 6 of this section.

(7) To remove the spark plugs, loosen the spark plug terminal elbow coupling nut from all spark plugs. Withdraw the elbows from all spark plugs and remove the plugs. Use spark plug wrench (Tool No. 84450) for 7/8 inch hexagon spark plugs and wrench (Tool No. 84414) for 1 inch hexagon spark plugs. See figure 45. Place the plugs in a board having drilled holes to accomodate the electrode end of the plug. Install vented dummy plugs in the spark plug holes in all cylinders. Install a cover (Tool No. 803837) over the exhaust port in all cylinders.

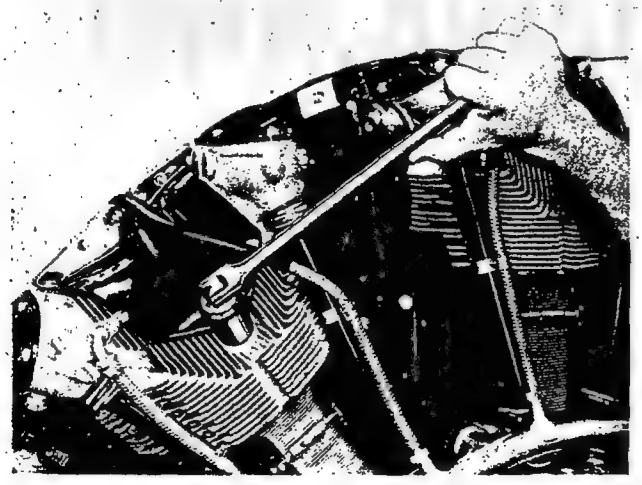

Figure 45—Removing Spark Plug

(8) Turn the crankshaft until the piston of the cylinder being removed is at the top of its stroke. Remove the lock wire from the cylinder hold-down cap screws and remove the cap screws. Use wrench (Tool No. 82750) for 9/16 inch hexagonal cap screws. Remove the spherical seat washers from the cylinder flange, and pull the cylinder out straight clear of the piston. See figure 46.

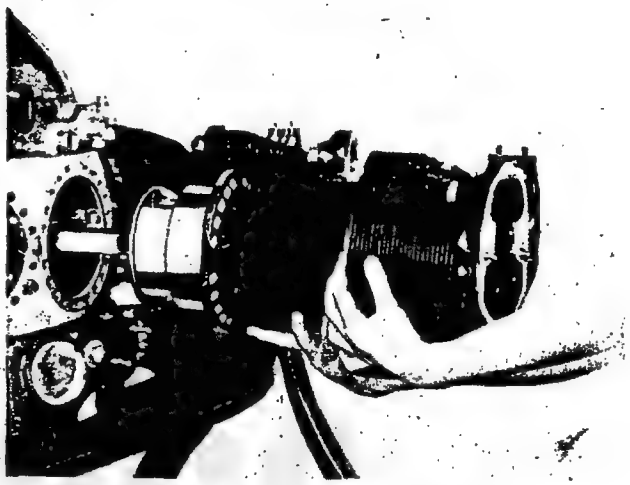

Figure 46—Removing Cylinder

(9) As the cylinder is being removed from the engine, but before the cylinder skirt clears the bottom piston ring, a cloth should be drawn around the connecting rod and spread over the cylinder hole to prevent pieces of broken piston ring from falling into the crankcase.

(10) Install an articulated rod guide on the cylinder pad, and secure it temporarily with two cap screws. See figure 47. Install a fin protector around the cylinder if the cylinder is to be used again.

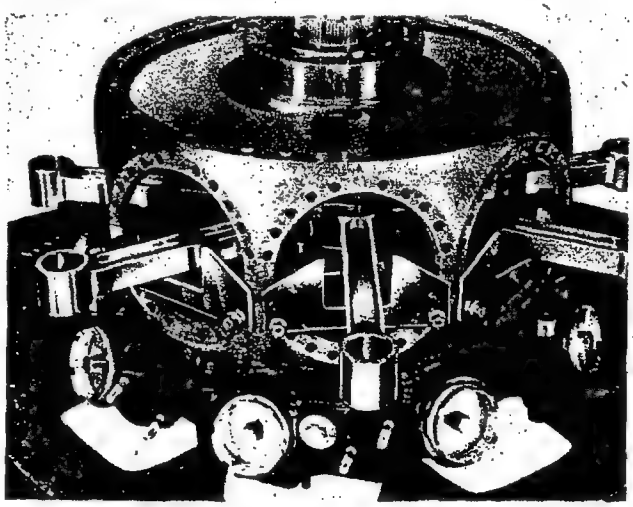

Figure 47—Articulated Rod Protectors

b. PISTON REMOVAL.

(1) Remove both piston pin retainers, using Tool No. 803299. Insert the spade-shaped end of the tool between two of the coils of the spring and turn the handle 90 degrees. Pry out the spring, resting the leg of the tool against the wall of the piston. Place one hand over the piston pin bore to catch the retainer as it is pried out. Figure 48 shows the application of the

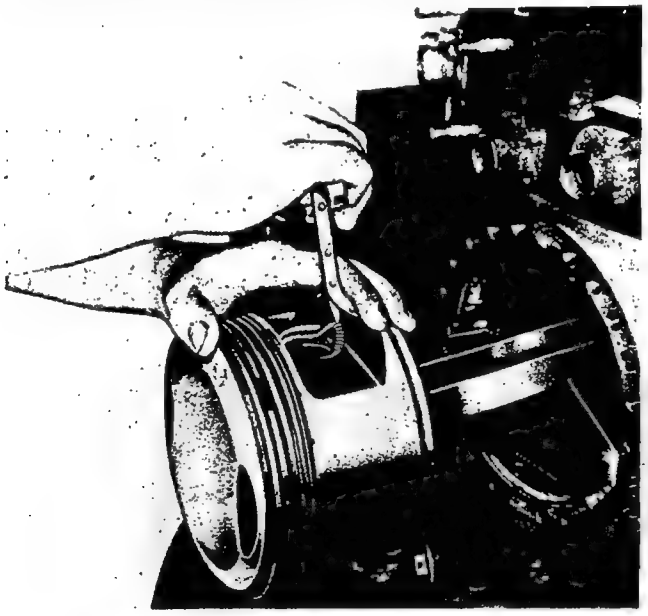

Figure 48—Removing Piston Pin Retainer

retainer removing tool. Always remove the master rod cylinder and piston last. Discard all used piston pin retainers.

(2) Push the piston pin out of the piston with the fingers. If the pin is tight or stuck, it may be removed with Tool No. 83243. Encircle the piston with the felt-lined stirrup of the tool and turn down the spindle which forces out the piston pin. Cover the cylinder pad on the crankcase to prevent the entrance of any foreign material. Figure 49 shows application of piston pin removing tool.

c. PISTON INSTALLATION.

(1) Install a new piston pin retainer in the rear piston pin retainer groove of each piston in the following manner: Place the retainer in the installing tool (Tool No. 84861) with the spring joint approximately 90 degrees either side of the cut-out in the tool. Install the piston pin in the piston with the large diameter of the chamfer flush with the inner edge of the retainer groove. Insert the end of the installing

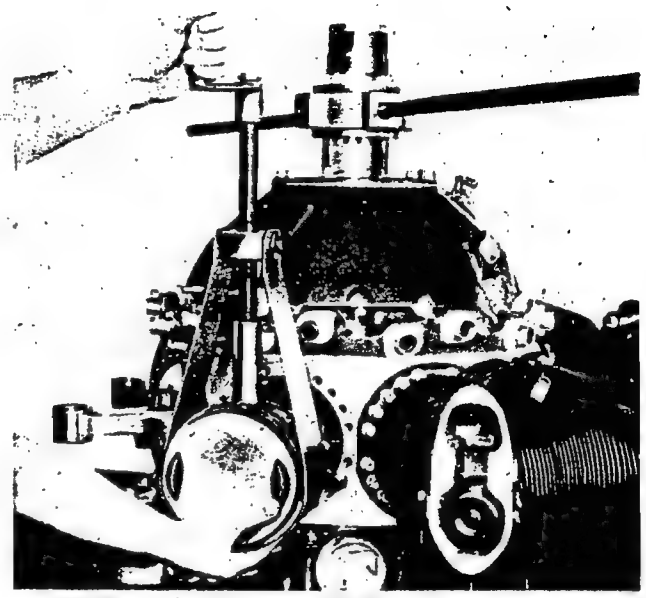

Figure 49—Removing Piston Pin

tool in the piston pin from the side of the piston in which the retainer is to be installed with the cut-out portion of the tool at the top of the piston pin hole. While performing this operation, locate the top section of the retainer spring in the top section of the groove. Install the adapter in the opposite end of the piston pin and while holding the pin in position with one hand, apply pressure on the installing tool with the other and force the spring into its seat in the retainer groove. Remove the installing tool and piston pin. See figure 50.

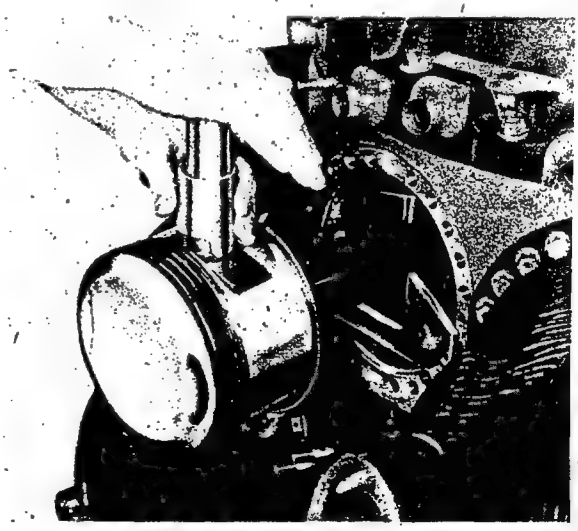

Figure 50—Installing Piston Pin Retainer

(2) Turn the crankshaft so that the connecting rod is at the top of its stroke. Oil the piston pin, connecting rod, piston pin bushing, and piston pin bore with clean engine lubricating oil. Install the piston so that the part numbers stamped on the dome of the piston face the front of the piston. Insert the piston pin so that it bottoms against the retainer spring previously installed. Install the remaining retainer in the same manner as the first, using the installing tools.

d. CYLINDER INSTALLATION.

(1) Coat the cylinder barrel bore with clean engine oil and install a new oil seal ring below the hold-down flange. Thoroughly coat the piston and rings with clean engine oil. However, do not use excessive oil as drainage into the combustion chamber may cause fouling of the spark plugs. Set the piston rings so that the gaps are equally spaced (staggered) around the piston. Remove the connecting rod guide from the cylinder pad. Make sure that the cylinder pad is clean and dry.

(2) Compress the upper piston rings with the flexible piston ring clamp (Tool No. 80440) and slide the cylinder over the piston. See figure 51. As soon

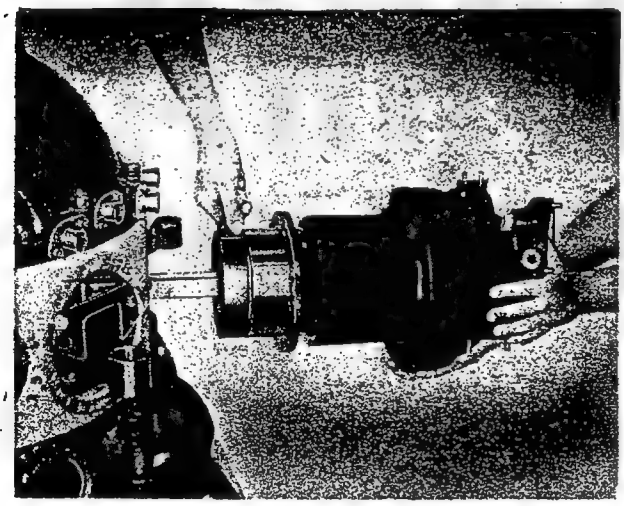

Figure 51—Installing Cylinder

as the top five rings have entered the cylinder, remove the clamp and inspect the piston pin retainers to insure that they are in their proper position. Install the clamp over the single lower ring, compress the ring, and slide the cylinder into its proper location on the crankcase.

(3) Apply a small amount of engine oil, Specification No. AN-VV-O-446a, to the threads of the two special cylinder hold-down locating cap screws, part No. 84501, and install these cap screws on opposite sides of the cylinder. Use the special offset box-socket wrench, tool No. 82750 or 82860, depending on the size of the cap screw, and torque handle, tool No. 84922. AAF personnel will tighten these cap screws to a torque of approximately 300 inch-pounds. Navy personnel will tighten these cap screws to a torque of 300 to 425 inch-pounds. This will prevent any misalignment of the hold-down cap screws and incorrect seating of the spherical washers. These special locating cap screws are copper plated, and have integral spherical seats, but do not have holes drilled for safety wiring. Lubricate the regular hold-down cap screws with a small amount of engine oil, Specification No. AN-VV-O-446a, and install them fingertight with spherical seat washers under the heads. Place the radio shielding clips (if used) on their proper locations, sandwiched between the head of the cap screws and spherical seat washers. Do not install clamps, brackets, or other washers under the cylinder hold-down cap screw, except those supplied with the engine.

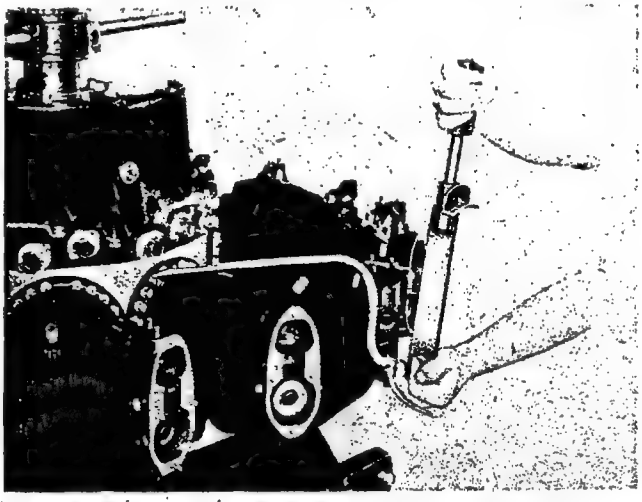

Figure 52—Tightening Cylinder Hold-down Cap Screw

(4) AAF personnel will tighten two cap screws on opposite sides of the cylinder at approximately 90 degrees from each of the special locating cap screws to a torque of approximately 300 inch-pounds. Navy personnel will tighten the cap screws to a torque of 300 to 425 inch-pounds. Install two more cap screws on opposite sides of the cylinder about 45 degrees from the previous pair, and tighten to the same torque. Proceed in the same manner until all cap screws are tightened. Remove the special locating cap screws and replace them with standard cap screws and washers. Finally, tighten all of the cap screws consecutively around the cylinder, using the torque specified in the Table of Limits, AN 02-35-1. (See figure 52.)

(5) The following precautions will be observed when using a torque wrench:

(a) Make sure the wrench does not bind on any part of the engine.

(b) Install the wrench in such a position that the cap screw may be pulled up to the required tightness without interruption.

(c) The torque load should be applied until the bolt has ceased to turn. This requires several seconds

from the time that the indicator reaches the desired torque value.

(6) Install the spark plug loosely in the cylinder head to prevent the entrance of foreign material.

(7) Lockwire the cylinder hold-down cap screws, using a length of wire for each group of five cap screws. Twist the wire one turn between cap screws and together securely at the ends.

(8) Install the cylinder barrel air deflectors in accordance with the procedure outlined in paragraph 3 of this section.

(9) For cylinders No. 5 and 6 it will now be necessary to install the sump according to the instructions set forth in paragraph 8 of this section.

(10) Install the intake pipe on the cylinder being installed, as well as the adjacent intake pipe which was removed for accessibility. Instructions for this procedure are found in paragraph 5 of this section.

(11) Install the push rod housings, push rods, and rocker arms according to the procedure outlined in paragraph 9 of this section. If interference exists between the rocker arm and standard valve spring washer it will be necessary to replace the valve spring upper washer with one having an undersize bore. See figure 53. This requires removal of the cylinder to a valve

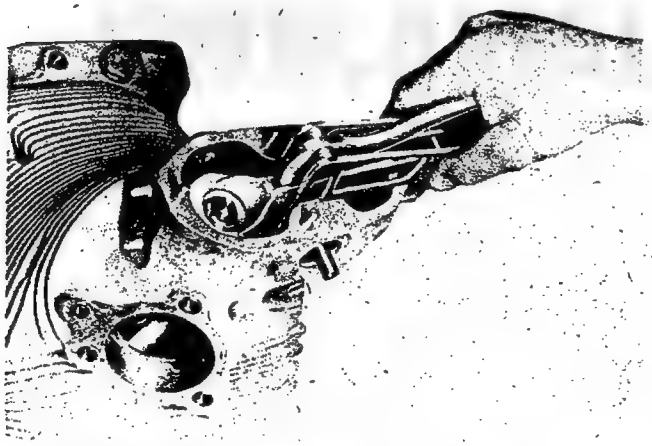

Figure 53—Compressing Valve Springs

assembly block as previously described in this section.

(12) After installation of any cylinder above the horizontal center line, fill the rocker boxes with engine oil to assure ample lubrication when the engine is started the first time. Install the rocker box covers with gaskets, using a plain washer, a shakeproof washer, and a nut on each of the attaching studs. Install the ignition wire attaching clips on the proper push rod housings and rocker boxes.

(13) Copper gaskets or thermocouples which conform to the thickness specified in paragraph 2 of this section are installed under the shell of each plug. Install and tighten the spark plugs to the proper torque value with wrench (Tool No. 84458 for plugs having a 7/8 inch hex. nut, and wrench, Tool No. 84457, for plugs with a 1 inch hex. nut). See figure 54.

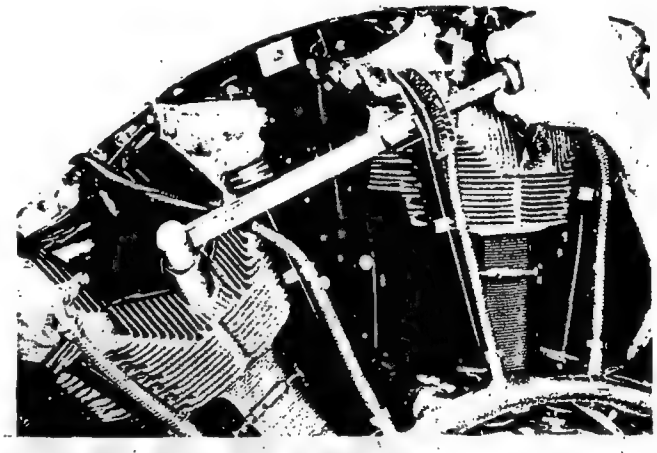

Figure 54—Installing Spark Plug

(14) On cylinders which were installed adjacent to the two main radio shielded ignition conduits, it will be necessary to attach the retaining yokes and tighten the couplings of the radio shielding.

(15) Install the cylinder head air deflector unit according to the instructions given in paragraph 3 of this section, and connect the spark plug ignition terminals.

(16) Install the exhaust stacks which were removed and reassemble the portion of the exhaust manifold which was removed or swung out of the way for the cylinder removal. Tighten all joints.

e. ADJUSTMENT OF VALVE CLEARANCES.—Set the valve tappet clearance in accordance with the following instructions:

(1) Install the top center indicator in the front spark plug bushing of the cylinder in which the valve tappet clearance is being adjusted. See figure 55.

(2) Turn the crankshaft until the piston, in the cylinder on which the adjustment is being made, is at the top center position on the compression stroke (both valves closed) as shown on the indicator.

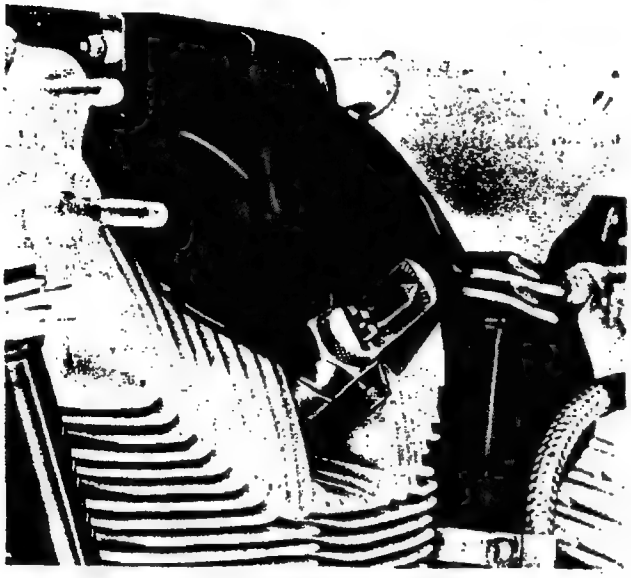

Figure 55—Top Center Indicator

(3) Loosen the adjusting screw lock screw. See figure 38. Screw in the adjusting screw until the rocker arm roller bears against the valve stem and the tappet spring is fully compressed. Tap the adjusting screw end of the rocker arm to insure that the spring is fully compressed.

(4) Turn the adjusting screw in a counterclockwise direction until desired clearance of .010 inch is obtained as indicated by a strip of feeler stock. See figure 56. Tighten the adjusting screw lock screw, using wrench (Tool No. 81900) and check the adjusting screw for tightness. Recheck the clearance.

CAUTION

Each valve clearance adjusting screw is marked on its outer face in line with the three radially drilled oil holes in the screw. Refer to Figure 57. When adjusting the

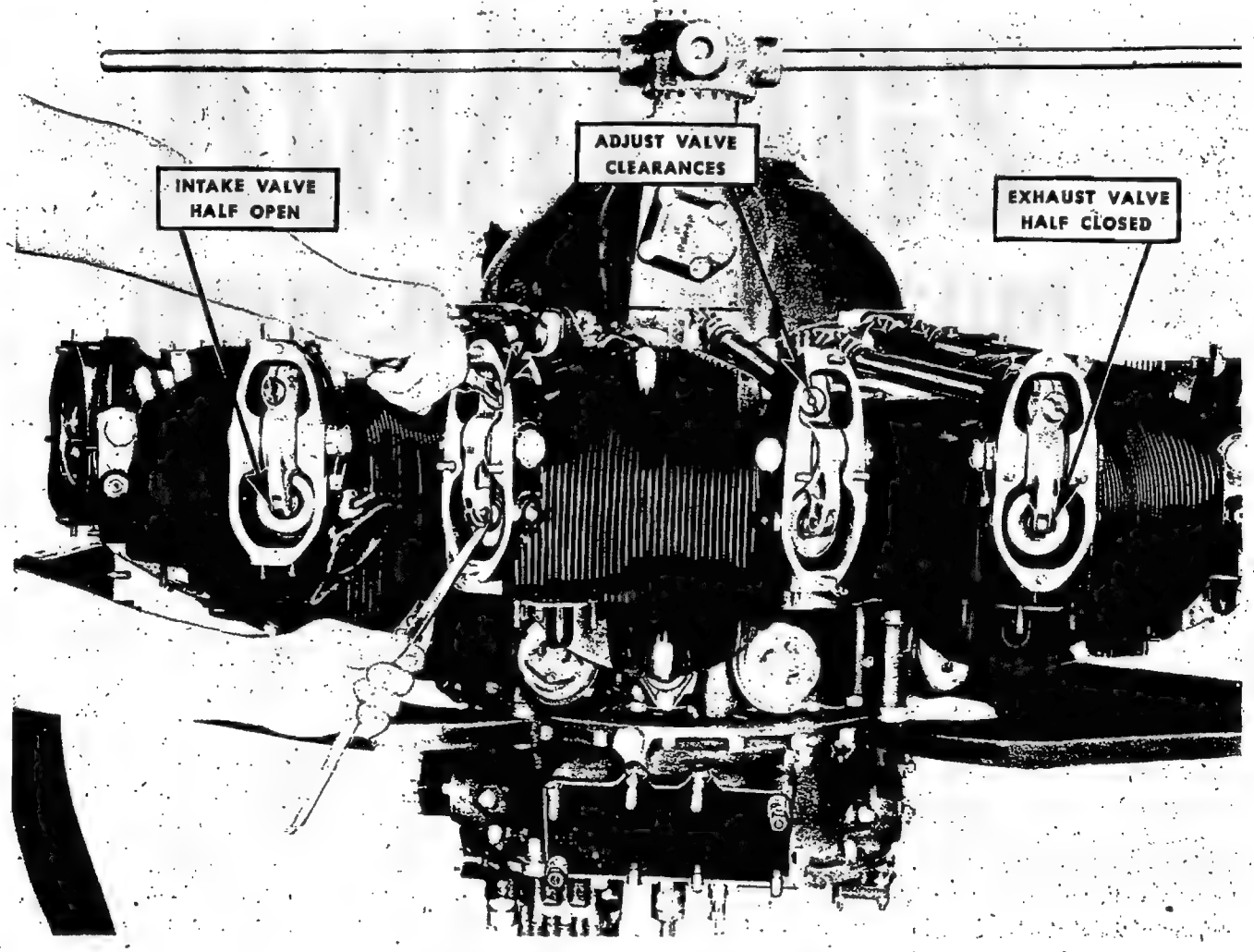

Figure 56—Adjusting Valve Clearance

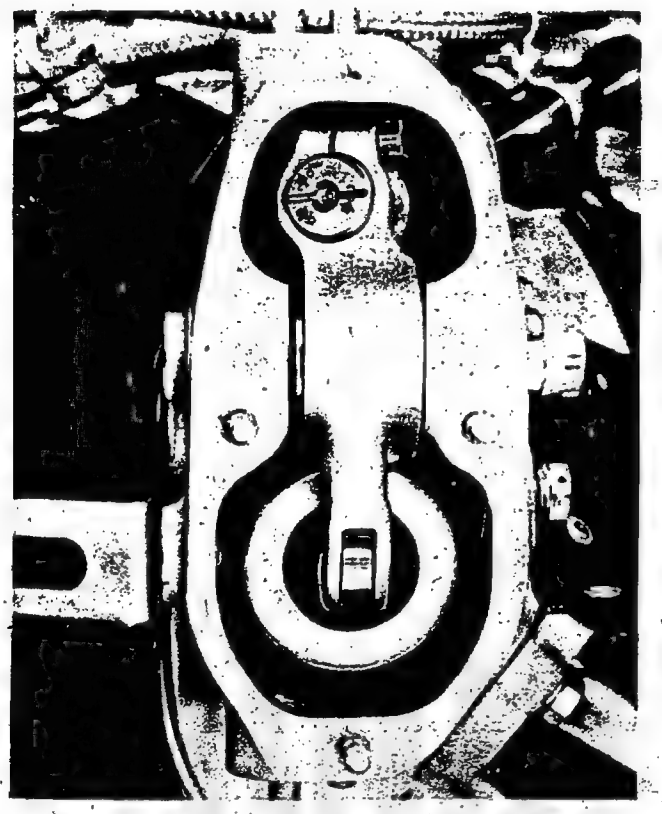

Figure 57—Location of Indexing Marks on Adjusting Screw

valve clearance insure that none of the drilled holes lines up with the split in the rocker arm. Insure that the hole is at least 1/8 in. from the nearest edge of the split in the rocker arm. If this condition is encountered after the .010 in. clearance has been set, it is permissible to turn the adjusting screw in the direction to increase the valve clearance until the oil hole is closed off by 1/8 in. or until .017 in. valve clearance is obtained, whichever occurs first. The tolerance + .007 — .000 in. is allowed only when necessary to prevent alignment of the oil hole with the split in the rocker arm, when the valve clearance is set to the standard figure.

(5) Adjust any remaining valve tappet clearances in accordance with the foregoing instructions.

11. BENDIX STROMBERG INJECTION CARBURETORS.

a. REMOVAL.

(1) Disconnect the throttle and mixture controls and remove all lines to connections in the carburetor and adapter. Remove all lines and heater controls from the air scoop.

(2) Remove the palnuts, nuts, and plain washers securing the air scoop to the carburetor and remove the air scoop. Remove the air screen to scoop gasket, screen, and screen to carburetor gasket.

(3) Remove the cotter pins, nuts, and spherical seat washers securing the carburetor to the supercharger rear housing. Remove the carburetor and gasket.

(4) Cover the opening into the induction chamber with a suitable cover or plate to prevent the entrance of foreign material into the induction chamber.

b. INSTALLATION.

(1) Before installing the carburetor, prepare it for service in accordance with the instructions given in section IV.

(2) Remove the cover plate from the mounting pad on the supercharger rear housing. Install a new gasket over the mounting studs. Place the carburetor in position over the mounting studs and install the spherical seat washers. Install the nuts, drawing them up snugly against the washers. Tighten all the nuts evenly, lining up the cotter pin holes and cotter securely.

(3) Place a new gasket over the air scoop mounting studs and install the screen. Install a new gasket between the screen and scoop, and install the air scoop. Secure the air scoop with plain washers, nuts, and palnuts.

(4) Connect the throttle mixture and heater controls and all other connections to the carburetor, adapter, and air scoop.

(5) Check all controls for ease of operation and full travel.

12. IGNITION WIRE HARNESS.

a. REMOVAL.

(1) Disconnect the spark plug terminals from the front and rear spark plugs. Remove the clips securing the harness leads to the push rod housings and withdraw the ignition leads from the channel sections in the cylinder head air deflector.

(2) Remove the rocker box covers from the rocker boxes of cylinders No. 1—exhaust, No. 1—intake, No. 2—exhaust, and No. 9—intake.

(3) Remove the priming system tubes as directed in paragraph 4 of this section.

(4) Remove the cylinder barrel air deflectors from between cylinders No. 1 and 2, and No. 9 and 1. This may be performed in accordance with the instructions in paragraph 3 of this section.

(5) Remove the intake pipes of cylinders No. 1 and 9 as directed in paragraph 5 of this section.

(6) Remove the four clips securing the harness to the supports which are bolted to the crankcase front section at the housing parting surface location.

(7) Remove the two cap screws securing the top section of the radio shielding to each magneto. Remove the six cap screws from each magneto which secure the coil cover and retain the magneto blocks.

(8) Pull the section of radio shielding extending between the two magnetos straight up and disengage the two magneto blocks from the magneto housings.

(9) Remove the ignition wire harness complete with the magneto blocks from the engine, pulling it upward and to the rear.

b. DISASSEMBLY AND ASSEMBLY.

(1) If any part of the ignition harness is damaged, the part may be removed from the harness assembly by loosening either one or more of its adjacent knurled couplings and replacing with a new part.

(2) When replacing ignition wire, dust each wire with powdered talc, powdered mica, or DC-4 and start it through the aperture in the harness, using a rotating motion and exerting a very slight pull.

(3) If a spark plug terminal is replaced or reinstalled, the following procedure should be used:

(a) Straighten out the ignition cable strands which are fanned out at the base of the coiled contact spring and pull the spring and sleeve assembly from the end of the cable. Loosen the knurled coupling securing the terminal elbow to the spark plug conduit, and withdraw the elbow and rubber packing gland.

(b) Install the replacement spark plug terminal elbow, using a new rubber packing gland.

(c) Make sure the contact spring and washer assembly are not loose in the terminal sleeve of the replacement terminal. This may be checked by inserting a 1/4 inch diameter rod in the sleeve bottoming on the contact washer. Place the other end of the rod on a scale and hold the sleeve with the fingers. Press down on the sleeve with a 12 to 13 pound load and observe the washer and sleeve for movement. Repeat the procedure with the sleeve inverted on the rod. If the contact washer moves in either direction, the sleeve assembly should be replaced.

(d) Twist the ends of the ignition cable slightly and insert the cable in the contact sleeve. The stripped end of the cable should protrude through the hole in the washer at the base of the contact spring about 1/8 inch. Fan the strands of cable around the washer and press the strands securely into position over the end of the contact washer nipple by means of a short copper tube (1/8 inch inside diameter).

(e) Insure that the terminal sleeve fits snugly into the recess in the terminal elbow and tighten the knurled coupling nut securing the terminal assembly to the radio shielding.

(4) To separate the magneto block from the ignition cables, observe the following:

(a) Remove the two slotted cap screws from each side of the magneto block housing and the two nuts and bolts at the top of the housing. The housing may be separated and removed from the magneto block.

(b) Remove the cable piercing screws adjacent to the electrodes in the distributor block and withdraw the ignition cables. Remove the booster cable, if provided, by removing its piercing screw.

(c) The block may now be separated from the ignition cable assembly.

(5) To assemble the magneto distributor block to the ignition cables, proceed as follows:

(a) Insert the cables through the radio shielding if the shielding was removed. Insert the cables through the ignition wiring harness attaching flange at the top of the magneto, if removed.

(b) Apply powdered talc or mica to the cables before inserting in the distributor block holes.

(c) A brass washer is placed over the end of the ignition cable which is inserted in the magneto block. The cable strands are folded back under the washer to insure good contact and each washer is stamped with its distributor block number. See figures 58 and 59. Insert each ignition cable in its corresponding hole in the distributor block as denoted by the numbers on the washer and the magneto block. The numbers on the magneto denote the serial firing order of the magneto and not the cylinder numbers. See figure 60. Make sure that the cables bottom in the holes in the distributor block and screw down each cable piercing screw to insure security and proper contact. No lock

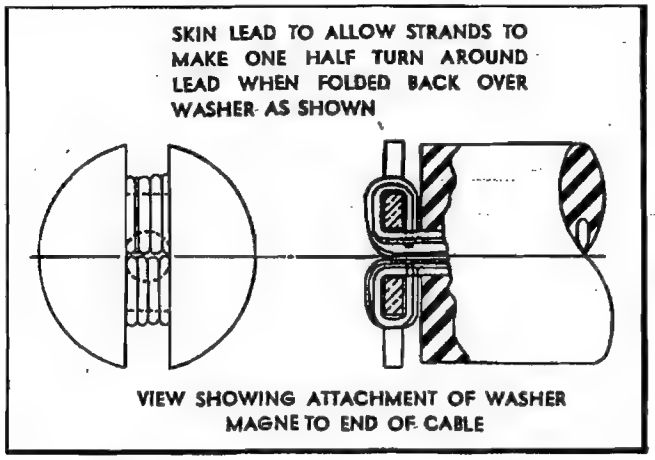

Figure 58—Method of Installing Washer on Ignition Cable

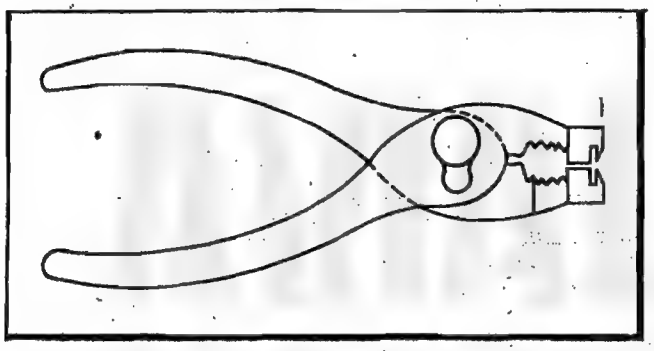

Figure 59—Special Pliers Used to Install Washer on Ignition Cable

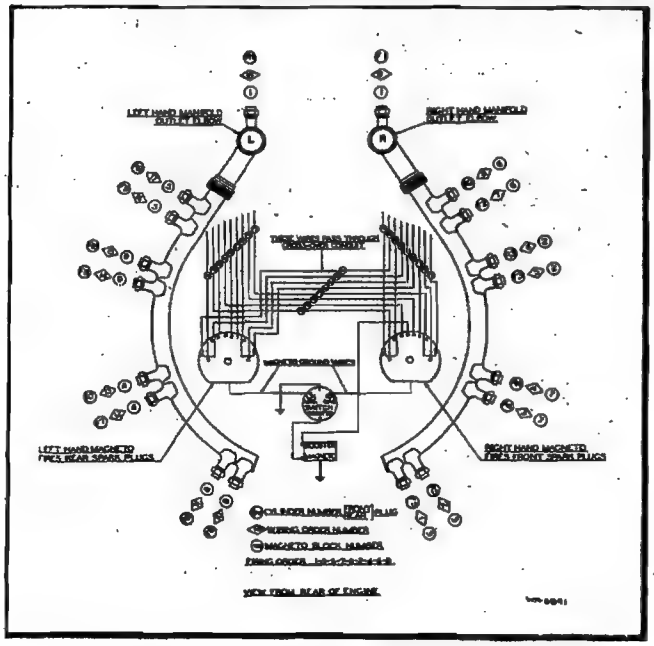

Figure 60—Ignition Wiring Diagram

washers are employed under the cable piercing screws. See figure 61.

Figure 61—Inserting Ignition Cable Piercing Screw

(d) If a booster magneto cable is employed, insert its end in the distributor block cable hole marked "B" and secure it with the cable piercing screws.

(e) If no booster wire is used, insure that a lock washer is installed under the head of the cable piercing screw.

(f) Install the two halves of the distributor housing and secure with the slot-head screws and the nuts and bolts at the top of the housing. Tighten all the remaining screws retaining the housing assembly.

(6) Before installing the ignition shielding assembly, check the ignition wiring for shorts or open circuits and to ascertain whether the ignition cables lead to the proper cylinder from the magnetos.

(a) To test for a short circuit due to faulty insulation of the cable, a booster magneto should be used. Connect the high tension terminal of the booster magneto to a distributor block electrode and hold the spark plug end of the corresponding ignition cable about 3/8 inch from a suitable ground. If a good spark does not jump the gap, examine the cable for faulty insulation.

(b) To test for an open circuit in a cable and to check the firing order of the cylinders, a buzzer or light system should be used. Touch the distributor

block electrode with one contact and the spark plug end of the cable with the other contact. The circuit is complete if the buzzer signals or the lamp lights. If the circuit is not complete, check for possible open circuit or wrong connection of the cables.

(c) The following table gives the relation between the cylinder and magneto firing order:

Magneto Distributor Block No.	*Cylinder No.*
1	1
2	3
3	5
4	7
5	9
6	2
7	4
8	6
9	8
P	Magneto Ground
B	Booster Magneto

(d) Tighten all the knurled shielding coupling nuts and cap screws.

(7) INSTALLATION.

(a) Place the ignition harness in its approximate position on the engine. Insert the magneto distributor block in its recess in the magneto housing using extreme care not to damage the contact buttons.

(b) Place the magneto coil cover in its position on the magneto and secure both the magneto distributor block and the coil cover with the six slot-head cap screws using a new lock washer under the head of each cap screw.

(c) Install the four clamps securing the two halves of the ignition harness to the four supports which are bolted to the crankcase front section.

(d) Attach the flexible radio shielded ignition leads to the push rod housings by means of the clamps and secure the ignition leads for the front and rear of each cylinder together by means of clamps to prevent vibration of the leads.

(e) Install the cylinder barrel air deflectors as outlined in paragraph 3 of this section.

(f) Install the priming system tubes and intake pipes as directed in paragraphs 4 and 5, respectively, of this section.

(g) Place the rear ignition leads in their respective locations in the channel sections of the cylinder head air deflectors and attach the terminals to the spark plugs. Attach the front spark plug terminals to their respective spark plugs.

c. MAGNETO GROUND TERMINAL.

(1) REMOVAL.

(a) Loosen the knurled coupling joining the radio shielded ground wire to the "Y" junction.

(b) Loosen the knurled coupling joining the radio-shielded ground wire which interconnects the two magneto ground junctions.

(c) Remove the bail wire from the castellations on the ground terminal retaining nut and withdraw the magneto ground terminal assembly complete.

(d) Pull the brass contact away from the rubber washer and insulating sleeve and melt the solder at the ends of the contact. Withdraw the wire from the contact and sleeve assembly.

(2) INSTALLATION.

(a) Strip back the insulation from the ground wire for about 3/16 inch and twist the wire slightly. Install the insulating sleeve with the flange toward the end of the wire. Install the rubber washer and insert the wire through the brass contact button. Pull the insulating sleeve and rubber washer away from the contact and fan the wire out slightly. Solder the wire to the contact button and file the solder flush with the end of the contact.

(b) Insert the ground terminal into the sleeve in the magneto breaker housing and secure the assembly with the knurled nut. Lock the knurled nut with the spring wire lock ring.

(c) Tighten the knurled coupling nuts securing the radio shielding at both ends of the "Y" terminal or install the cap if the terminal is not used.

13. SCINTILLA MAGNETOS.

a. REMOVAL.

(1) Remove the magneto air blast tube, if used. Remove the coil cover and distributor block in accordance with instructions in paragraph 12 of this section.

(2) Remove the magneto ground terminal as directed in paragraph 12 of this section.

(3) The Scintilla SF9LN4 magnetos have a detachable distributor block shrouded by a two-piece radio shield. Radio shields for right- and left-hand magnetos differ slightly. In view of the fact that all the high-tension ignition wires are secured to the dis-

tributor blocks, the block and radio shield of a magneto being locked, are also used in a replacement magneto of the same type, unless the block requires repair. The magneto cover encloses the coil and supports the distributor block. The cover may also be used on a replacement magneto of the same type.

(4) Remove the breaker housing cover which exposes the cam and pivotless contact breakers in the housing.

(5) With the ignition switch "OFF" and the mixture control set in "IDLE CUT-OFF" turn the engine crankshaft in the direction of normal rotation, until the step cut in the breaker cam "L" lines up with the timing mark "M" cut in the rim of the breaker cup, as indicated by a straight edge "K" (preferably a steel scale). See figure 62 for designated details. At this

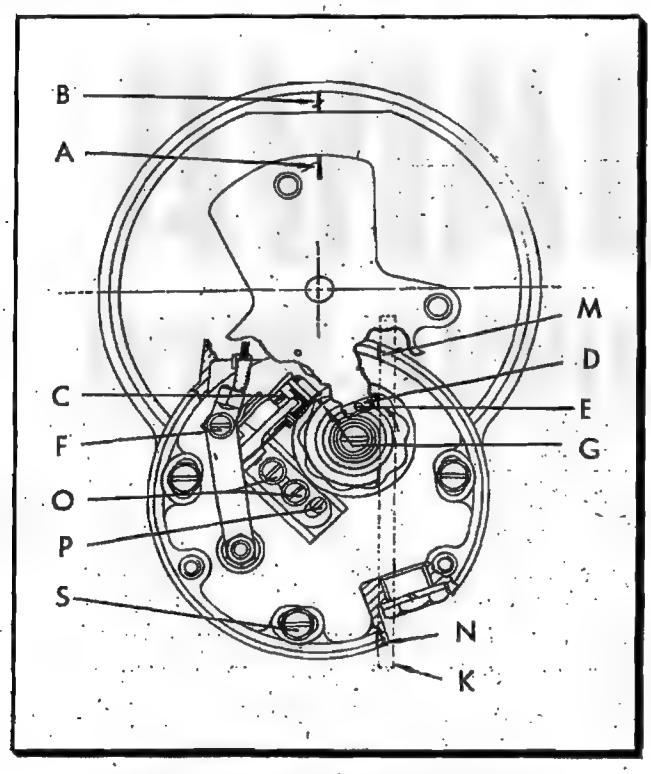

Figure 62—Magneto Timing Diagram

point the timing marks "A" on the distributor rotor will coincide with the mark "B" on the magneto front end plate indicating that the rotor is in a position to distribute a spark to No. 1 cylinder.

(6) The following procedure is recommended in removing a magneto in the event that the timing hole plug in the crankcase front section is not accessible. If the timing inspection hole in the crankcase front section is accessible, the procedure outlined in paragraph (7) below is the easiest and preferred method.

(a) Connect an A-100 Abbott timing light, AAF stock No. 8042-273875, across magneto breaker points and to ground. If a timing light is not available, use a 0.0015-inch steel feeler gage between the contact points "C" by lifting the felt-covered cam follower "F" which causes the points to open. If the breaker point spring is lifted to insert the feeler between the points, a permanent set may result from excessive bending. If the points are open, insert feeler gage and turn engine crankshaft slightly in opposite direction to normal rotation, or continue rotating in normal direction until breaker points are closed with the felt-lined follower resting on the flat of the cam preceding the lobe which opens the breaker points to furnish number one cylinder with its firing spark. Now turn crankshaft slowly in normal direction and pull lightly on feeler gage. Stop turning the crankshaft at the instant the feeler gage starts to slip or the timing light indicates the breaker points are open. Remove cotter pins, castellated nuts, and washers from each of the three magneto attaching studs, holding the magneto to keep it from dropping.

CAUTION

Do not disturb the engine crankshaft setting thus obtained until the replacement magneto has been installed.

(7) If the timing inspection hole in the crankcase front section is accessible for installing the replacement magneto, the inoperative magneto may be removed as soon as its timing marks have been aligned according to paragraph (5) above. Remove the magneto as previously described.

b. INSTALLATION.

(1) Remove the coil cover distributor block and breaker cover, if installed, from the replacement magneto. Scintilla pivotless-type contact breakers used in this series magneto must always be adjusted so that the contacts open at the proper position of the breaker cam in relation to the timing marks on the rim of the breaker cup and not for any fixed clearance between contacts. Before installing the replacement magneto,

first check the adjustment of the breaker contacts as follows:

(a) Lift the cam follower "F" and wipe the contact points with a clean, dry, lintless cloth.

(b) Turn the magneto drive shaft in the direction of normal rotation until the step cut in the breaker cam "L" lines up with the timing marks "M" cut in the rim of the breaker cup as indicated by a straight edge "K" (preferably a steel scale). See figure 62. At this point the timing mark "A" on the distributor rotor will coincide with the mark "B" on the front end plate, indicating that the rotor is in a position to distribute a spark to No. 1 cylinder.

(c) Connect an A-100 Abbott timing light across the points or, if a feeler gage is used, insert gage between the contact points "C" by lifting the felt-covered cam follower "F" which causes the points to open. Turn the engine crankshaft until the breaker points open as indicated by the timing light or by the feeler gage slipping. Stop turning the crankshaft at this instant. Place a straightedge across the face of the step cut in the cam and check the alignment with the timing marks "M" in the ring of the breaker cup.

(d) If the straightedge does not coincide with the timing marks, turn the magneto shaft until the alignment is made, keeping the timing light connected or the feeler gage between the points. Loosen the two screws "O" which fasten the breaker assembly to the breaker housing. Hold the magneto shaft in the aligned position and adjust the eccentric "P" so that contact points are just beginning to open. Tighten the retaining screws "O" and recheck the adjustment.

(2) With the adjustment thus obtained the poles of the rotating magneto are in a position where the maximum energy has been stored in the magnetic circuit when the breaker points open to cause a high-tension spark to be delivered to the spark plug.

(3) If the timing plug on the left-hand side of the crankcase front section is accessible, break the lock wire and remove the plug with its copper asbestos gasket. If the crankshaft has not been disturbed since the magneto was removed, following the procedure given in paragraph *a.* above, the piston in No. 1 cylinder should be near the top of its compression stroke. Looking through the timing inspection hole a crank angle degree scale ranging from 0 to 35 degrees before top center on No. 1 piston is seen etched on the rim of the reduction driving gear. See figure 63. Move the propeller until the line scribed on the rear of the timing inspection hole indicates that the No. 1 piston is located at the crank angle degrees before top center corresponding to the spark timing value stamped on the engine data plate for the magneto being installed.

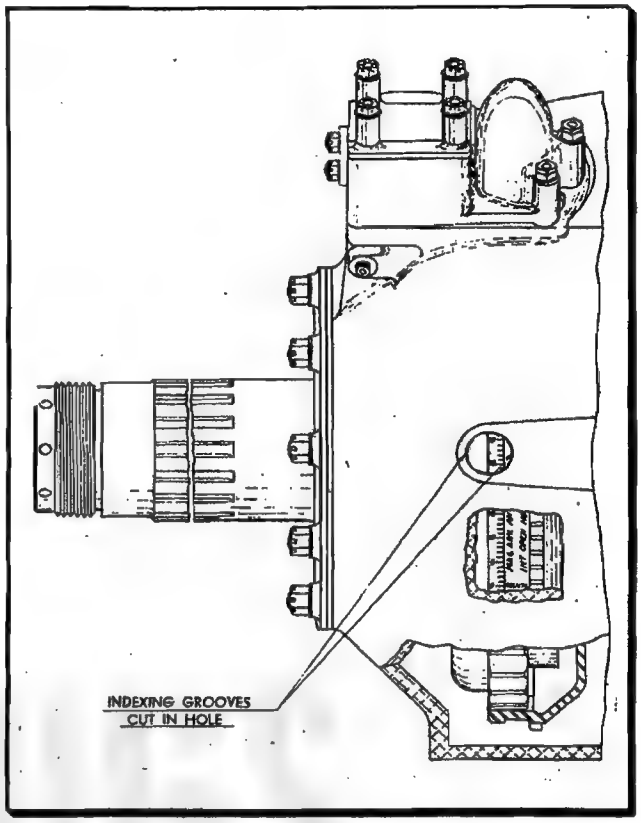

Figure 63—Timing Marks on Reduction Driving Gear

(4) In the event that the timing plug hole in the crankcase front section is not accessible, the crankshaft setting obtained prior to the magneto removal as described in paragraph *a.* (6), above, should be used for the installation of the replacement magneto.

(5) Apply a heavy grade of petrolatum to the splines of the magneto drive shaft coupling. With the distributor rotor held in the position to fire No. 1 cylinder as obtained in paragraph *b.* above, install the magneto on the supercharger housing rear cover mounting pad. Having the splined magneto coupling inserted into the mating splined end of the engine magneto drive gear, move the magneto to its extreme positions allowed by the slots in the mounting flange noting if the breaker points open and close. If the

breaker points open and close, assemble a flat washer and a castellated nut on each of the three attaching studs sufficiently tight to hold the magneto firmly on the cover but not tight enough to prevent adjusting the position of the magneto.

(6) If the points do not open and close when moving the magneto from side to side, withdraw it from the engine. Install the magneto coupling wrench over the splined drive shaft coupling to keep the shaft stationary, and remove the cotter pin, castellated nut, and washer which retain the coupling on the shaft. The coupling, which is fitted to the shaft by six slots on its inside diameter, should be withdrawn, turned to the next slot engaging position, and reinstalled on the shaft. Install the retaining washer and nut and check the opening and closing of breaker points with the magneto on the engine. When the results are satisfactory, withdraw the magneto to install the cotter pin in the coupling retaining nut, and reinstall the magneto on the engine as directed in paragraph (5) above. All adjustments must be made at the drive end of the magneto by changing the location of the coupling splines and not by altering the breaker point opening adjustment.

(7) Move the magneto in the direction opposite to crankshaft rotation until the breaker points open; connect the timing light, or insert the feeler gage between the points. Move the magneto as far as it will go in the direction of crankshaft rotation so that the breaker points have closed. Turn the magneto slowly back in the opposite direction until the breaker points are just beginning to open as indicated on the timing light or the feeler gage.

(8) Check the setting by turning the propeller backward a quarter of a revolution with the timing light connected or the feeler gage between the points. Rotate the propeller forward slowly, stopping when the points are just beginning to open as indicated by timing light or feeler gage. (See figure 64.) The crank angle degree reading observed on the reduction drive gear through the crankcase front section timing plug hole should correspond to the engine data plate spark advanced at the instant the points open as indicated by the timing light or the feeler gage. Install the cotter pins in the magneto flange attaching nuts when the correct spark advance has been established.

(9) Install the plug in the timing inspection hole in the crankcase front section with the copper-asbestos gasket under its head. Tighten and lockwire.

(10) Install the breaker housing cover and tighten the two hex-head cap screws which are retained in the cover by circlets. Check the cap screws for a lock washer under the head of each.

(11) Reinstall the distributor block, coil cover, radio shielding and ground terminal as described in paragraph 12 of this section.

14. AMERICAN BOSCH MAGNETOS.

a. GENERAL.—The American Bosch SF9LU-3 is a nine-cylinder, fixed-ignition, four-pole, flange-mounted type magneto and is driven directly through a splined drive coupling. The magneto drive shaft which turns at one and one-eighth engine speed rotates the nine-lobe compensating breaker cam at one-half engine speed. This magneto is completely radio-shielded. The magneto housing is an aluminum alloy casting. A separate forged duralumin mounting flange, held to the magneto housing by six staked fastening screws, forms an integral part of the housing assembly. Under no circumstances are these screws to be removed.

b. REMOVAL.

(1) Unfasten the lock spring, unscrew the slotted nut and give the switch cable a slight pull which will allow the insulation gland and terminal, including the terminal nut assembly, to be withdrawn completely.

(2) Disconnect the ignition harness coupling from the radio shield outlet. Remove the two radio shield outlet hold-down screws. Open the radio shielding assembly by withdrawing the screws.

(3) Remove the two fastening screws holding the radio shield to the gear housing. Also remove the two fastening screws holding the radio shield to the dust cover. Withdraw the halves of the assembly.

(4) Loosen the dust cover, including the booster conductor assembly, by removing the two fastening screws. Raise the cover slightly and push toward the engine. Remove the two distributor block fastening nuts. Lift the block vertically, remove the insulation plate by hand, and disconnect the spark plug cables by loosening the piercing screws.

(5) Disconnect the booster cable, if used, from the booster conductor by loosening the cable piercing screw. Withdraw the loose dust cover by withdrawing the two screws. After the removal of the three nuts on the flange securing studs, the magneto can be taken from the engine.

c. INSTALLATION.

(1) Correct internal timing of the magneto has been accomplished at the factory or at the overhaul shop so that the magneto is ready to be mounted to the engine. The breaker contact point opening has been adjusted to .009—.010 inch. Bring the piston of No. 1 cylinder to 20 degrees before top center on the compression stroke for both magnetos.

(2) Remove the radio shield, dust cover with booster conductor assembly, distributor block and breaker cover. Turn the magneto drive shaft in the direction of normal rotation, as indicated by an arrow on the cam, until the No. 1 lobe is about to open the contact points. The No. 1 cam lobe is marked by a red dot on the face of the cam. When facing the magneto drive shaft end, this position can also be observed by the white mark on the distributor gear on the side nearest the coil, and the white mark on the red pad on the inner face of the gear housing. When these two points are in line, the No. 1 lobe of the cam is about to open the contacts for firing No. 1 cylinder. Determine the exact breaker point opening by inserting a .001 inch feeler gage between the points, or connect a timing light across the points. The correct instant is determined when a slight pull releases the gage or when the timing light goes out. Hold the cam in this position either by pressing the fingers against the distributor gear or by holding the drive coupling so that the inductor rotor shaft cannot turn.

(3) Mount the magneto on the engine by means of mounting studs. It is important that these studs be approximately in the center of the magneto mounting flange slots. If the gear teeth of the magneto coupling will not mesh with the gear teeth of the engine drive in the position first tried, then remove the cotter pin, castellated nut, lock washer, recessed plain washer, and

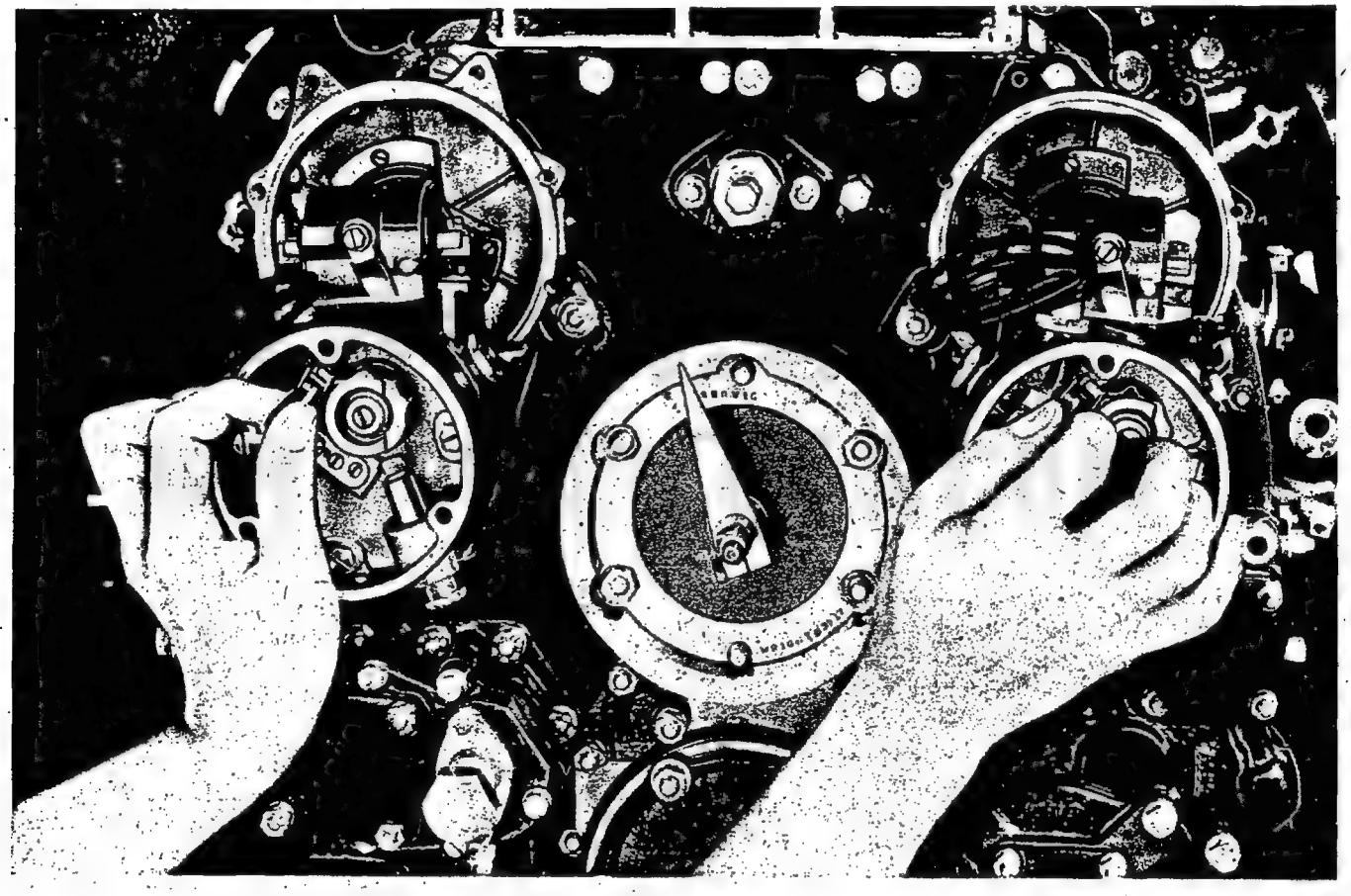

Figure 64—Timing Magnetos

withdraw the magneto coupling from the magneto drive shaft. Remount the magneto coupling in a different position on the magneto drive shaft. The coupling and drive shaft are provided with six splines so that six different positions of the gear teeth on the coupling can be obtained.

(4) After the coupling has been mounted in a new position, repeat the procedure of mounting the magneto on the engine. One of the six positions of the magneto coupling will allow it to mesh readily with the internal spline on the engine drive, with the mounting studs in the middle of the magneto mounting flange slots.

(5) After determining this position, remove the magneto from the engine and secure the coupling with a recessed plain washer, lock washer, castellated nut, and cotter pin. Now reinstall the magneto in the correct predetermined position.

(6) When both magnetos have been mounted, tighten the holding nuts firmly against the mounting brackets, but loose enough so that they may be moved in their flange slots for final accurate timing adjustment to the engine.

(7) When making the final timing adjustments of the magnetos to the engine, all adjustments must be made through the drive coupling assemblies by turning the complete magnetos in their mounting flange slots. For synchronized sparks of both magnetos, both sets of points on No. 1 cam lobes must open simultaneously.

(8) Although final timing of both magnetos to the engine can be carried on at the same time, it is recommended that one magneto only be timed perfectly to the engine, and the second magneto be synchronized with the first one. This final timing and synchronization is done in the following manner: With piston of No. 1 engine cylinder in advance firing position required on the compression stroke and both magnetos having been mounted as outlined, proceed as follows:

(a) Assuming that the left-hand magneto is the one chosen for timing to the engine, loosen its holding nuts on the retaining studs of the mounting flange sufficiently to permit rotating the entire magneto slightly in its mounting flange slots. Rotate the magneto frame until its cam follower is in the cam dwell preceding No. 1 cam lobe, with the breaker points closed. Insert a .001 inch feeler gage between points, or connect a timing light across the points. Now rotate the magneto frame carefully until the feeler gage is released by a gentle pull or when the timing light goes out. To insure absolute accuracy, the contact opening position should be rechecked before tightening the fastening nuts sufficiently to prevent any movement of the magneto, but loose enough for further adjustment.

(9) Magneto timing should now be checked with engine timing marks by movement of the propeller. Rotate the propeller counterclockwise approximately one-quarter turn, then reverse rotation sufficiently to bring the cam follower into the cam dwell preceding No. 1 cam lobe. At this position, reinsert a .001 inch feeler gage between the points, or reconnect the timing light across the points. Continue to move the propeller in a clockwise direction by a very slight jarring movement until the engine timing pointer is at the engine timing mark. A slight pull on the feeler gage should release same, or the timing light should go out, under continued jarring action on the propeller while the engine timing pointer is within the engine timing mark. This setting should also be rechecked.

(10) Correct setting having been obtained, secure the left-hand magneto by means of the holding nuts.

DO NOT DISTURB THIS SETTING.

(11) With the engine and the left-hand magneto in the above position, adjust the right-hand magneto in its mounting slots until the breaker points just open, by using either the feeler gage or the timing light method. This is the synchronizing operation, and should be carried out carefully. The right-hand magneto should now be tightened, but only enough to permit further adjustment, if necessary.

(12) Check synchronization of the magnetos with the engine by turning the propeller counterclockwise approximately one-quarter turn, and then turning it clockwise until the cam followers are in the cam dwells preceding No. 1 cam lobes. Insert feeler gages between both sets of points, or connect two timing lights across them.

(13) Continue the clockwise movement of the propeller by a slight jarring action on the propeller. Both feeler strips must release at the same time, with equal efforts of pull, or both timing lights must go out at the same moment. If this instantaneous action is not obtained, any equalizing adjustments must be made on the magneto being synchronized—in this case the right-hand magneto. Retighten the fastening

nuts of both magnetos and secure them with cotter pins.

(14) Remove the insulation plate from the distributor block by hand and connect the high-tension cables. The spark plug cable for No. 1 cylinder is inserted in the distributor block cable hole marked No. 1 and secured with the cable piercing screw. Insert the cable for the cylinder next to fire, according to the engine firing order, into a distributor block cable hole marked No. 2, et cetera.

(15) Note that the numerals on the distributor block indicate the firing sequence of the magneto only, and must not be construed as the firing order of the engine. After all cables have been secured, insert the insulation plate in the distributor block.

(16) Replace the breaker cover, distributor block, dust cover with booster conductor assembly, and radio shield. When installing the latter, make certain that the screws holding the radio shield to the gear housing are tightened before the screws holding the shield to the dust cover are inserted.

15. EDISON-SPLITDORF SF9LD MAGNETOS.

a. INSTALLATION.

(1) With the radio shield and distributor block removed, turn the drive shaft until the arrow on the distributor finger is aligned with the engraved line on the lower face of the magneto housing. At this point, the notched lobe on the compensated cam should begin to open the contact points. Check this position with an A-100 Abbott timing light, AAF stock No. 8042-273875. In the event a timing light is not available, use a 0.0015-inch steel feeler gage. Hold this setting and place the magneto on the engine. Fasten screws lightly and recheck position of original timing.

(2) Where critical adjustments are necessary, the magneto may be shifted from side to side, taking advantage of the slots in the mounting flange. This variation is 5 degrees each way from the vertical center line. By the combination of the 17 teeth cut on the outside of the drive coupling and the 45 internal serrations matching up with the same number of serrations on the drive shaft, and a point-to-point movement of the coupling on the shaft serrations, an adjustment of one-half degree on the drive shaft is possible without disturbing the upright position of the magneto at any time.

(3) Since the timing of all aircraft magnetos is done in accordance with standard procedure, the usual practice should be followed with Edison magnetos. The timing disk pointer should register with the same full advance firing position marking of No. 1 cylinder, as always.

(4) It is very important that all magneto timing corrections be made on the drive, or coupling, end of the magneto. The breaker point setting should not be disturbed during the timing procedure, as this would throw the magnetic and electrical timing out of synchronism.

NOTE

Breaker point cleaning, setting, or adjusting should not be confused with the original timing of the magneto to engine instructions.

b. CABLING UP.

(1) Remove the distributor block from inside radio shield. Remove all the piercing screws. Insert spark plug cables through cable manifold. Select cable for No. 1 cylinder and insert to full depth in cable socket marked No. 1. Hold cable tightly in place and fasten with cable piercing screw. Repeat this procedure by arranging each cable for the proper firing order of the engine. The numbers stamped on the face of the distributor block indicate the magneto firing order only.

(2) Coating the cable ends with Dow-Corning's No. 4 Ignition Sealing Compound before they are entered into the cable wells of the distributor block helps materially to reduce the amount of spark creepage because of the presence of moisture on and around the spark plug cables at this point.

(3) After all the cable connections have been made, they should be checked as follows:

(a) Proper firing order

(b) Short circuit (grounded)

(c) Open circuit (no connection)

(4) The above tests can be made with the usual light, buzzer, or high-tension booster magneto.

(5) Before the distributor block is reassembled into the radio shield, apply a light film of Dow-Corning's No. 4 Compound to the sealing gasket located in the radio shield. Take up slack in cables and slide the distributor block back into the radio shield. Adjust position to permit entering the holding screws which should be tightened evenly.

16. CHECKING VALVE TIMING.

a. Check the valve timing by installing a top center indicator in the front spark plug hole of No. 1 cylin-

der. See figure 55. Mount timing disk (Tool No. 83517) with adapter (Tool No. 800947) on engines equipped with detachable starter dog of 12 teeth and the same timing disk with adapter (Tool No. 83533) on engines equipped with detachable three-jaw starter dog on the starter mounting pad and secure it with regular starter attaching nuts.

(1) Install engine turning hub (Tool No. 82889) on the propeller shaft and note the top center indicator pointer when the crankshaft is turned to determine if the pointer arm is contacting the piston properly. This may be ascertained by slowly turning the crankshaft until the piston nears the top center position and contacts the pointer arm. If the pointer arm is properly adjusted, the pointer will rise a few graduations as the piston approaches its top center position, pause for a moment and then return to its original position as the piston moves on its downward stroke. If the pointer moves upward off the graduated scale as the piston approaches top center, reverse the crankshaft rotation, remove the top center indicator and readjust the angle of the pointer arm in an upward direction. If the arm does not move, adjust it in a downward position. Repeat this procedure until the top center indicator is adjusted to register properly.

(2) Adjust the pointer on the timing disk to read zero when the top center indicator shows the piston in No. 1 cylinder to be on the top center of its compression stroke. This may be checked as follows: Turn the crankshaft in the direction of rotation until the pointer on the top center indicator is in the middle of the graduated scale. Note the reading in degrees indicated by the pointer on the timing disk.

(3) Continue to turn the crankshaft until the pointer on the top center indicator has completed its upward stroke and has returned to the point at which the first reading was taken. Again note the reading in degrees indicated by the timing disk pointer. The exact top center position is the point midway between the two timing disk readings.

(4) Turn the crankshaft in the opposite direction of rotation for approximately one-quarter turn, then turn it in the direction of rotation to the point midway between the two readings previously obtained and adjust the zero mark on the timing disk to coincide with the pointer.

b. Adjust the clearance of both valves to the timing value specified on the engine data plate.

(1) Turn the crankshaft in the direction of rotation until the piston in No. 1 cylinder is 30 to 35 degrees before top center on the exhaust stroke.

(2) From this point move the crankshaft forward slowly by tapping the turning hub handle until the No. 1 intake rocker roller just contacts the valve stem tip, indicating that the valve is starting to open. As soon as the roller tightens against the valve tip, note the reading on the timing disk. Continue to turn the shaft forward until the No. 1 exhaust rocker arm roller is free, indicating that the exhaust valve has closed and note the reading on the timing disk. If the cam gears have been meshed properly, the valve clearance adjusted accurately and the check carefully made, the readings obtained should check within a few degrees of the valve timing specifications given on the engine data plate. An error of one tooth made in the meshing of the cam gears will cause the readings obtained to vary considerably from the specified timing.

c. After completing the valve timing check, reset the valves in No. 1 cylinder following the instructions given in paragraph 10, *e,* (4) regarding the location of the oil holes in the adjusting screws. Pour one-half pint of engine lubricating oil into the rocker boxes, replace rocker box cover gaskets, and install the rocker box covers.

(1) Remove the timing disk from the starter mounting pad and reinstall the gasket and cover plate.

(2) Remove the top center indicator and reinstall the dummy spark plug. Install the plug in the front section inspection hole and secure with stainless steel lock wire.

17. STARTER REPLACEMENT.

a. The starter is secured to the supercharger rear housing cover mounting pad by six studs, washers, nuts, and palnuts.

b. Disconnect all lead and ground wires. Dismount starter by removing the six studs, washers, nuts, and palnuts.

c. When installing the starter, remove the gasket and wipe the mounting pad clean. Replace gasket and mount the starter on starter mounting pad.

d. Secure firmly with studs, washers, nuts, and palnuts. Connect all lead and ground wires.

18. GENERATOR REPLACEMENT.

a. The generator is secured to its mount pad in the supercharger rear housing cover directly below the starter by six studs, plain washers, nuts, and palnuts.

b. Disconnect all electrical wires attached to the generator.

c. Loosen and remove the six studs, washers, nuts and palnuts.

d. Remove the generator and gasket.

e. Place a cover over the generator mounting pad in order to prevent articles from falling into engine before the generator is installed.

f. Remove the cover and install a new gasket and generator.

g. Secure with studs, washers, nuts, and palnuts.

h. Connect all attaching wires.

19. FUEL PUMP REPLACEMENT.

a. The fuel pump is mounted on the right-hand side of the supercharger rear housing, slightly below its midsection. It is secured by four equally spaced studs, plain washers, and nuts.

b. Loosen and remove the studs. Remove the fuel pump gasket and fuel pump.

c. For installation, install the gasket and fuel pump and secure with studs, plain washers, and nuts. Attach the proper lines to the inlet, outlet, drain, and vent connections of the fuel pump.

20. FUEL PUMP DRIVE SHAFT AND OIL SEAL REPLACEMENT.

a. DISASSEMBLY.

(1) With the fuel pump removed from its mount pad, insert the two puller screws (Tool No. 84956) and remove the fuel pump drive shaft and support assembly as one unit.

(2) Insert a small diameter fiber drift in the outer end of the support and drive out the fuel pump drive shaft from its supporting bushings.

b. OIL SEAL REPLACEMENT.

(1) The fuel pump drive shaft oil seal assembly consists of a steel cup in which is assembled a leather seal reinforced by a coil-type spring. This assembly is replaced as one unit and cannot be disassembled.

(2) Remove the oil seal by inserting a drift in the inner end of the support and drive out the oil seal.

(3) Replacement of the oil seal is accomplished by pressing the new seal into its recess in the drive shaft support until the spring side of the seal bottoms in the recess. Use Tool No. 801534.

c. ASSEMBLY.

(1) Insert the drive shaft into the support with the gear end of the shaft towards the inner end of the support. Tap the gear into place until the shoulder at the inner end seats against the flange of the rear supporting bushing.

(2) Insert the support and drive shaft assembly into the supercharger rear housing, rocking it slightly to insure proper meshing of the gears. A new gasket should be installed under the flange of the support.

(3) Install the fuel pump as directed in paragraph 19 of this section.

21. DUAL ACCESSORY DRIVE ASSEMBLY.

a. ACCESSORY REPLACEMENT.

Provision for two optional small accessories is made possible by the use of a spur gear box attached to the supercharger rear housing cover at the accessory drive mounting pad. An accessory is secured to the attaching studs of the upper drive by plain washers, nuts, and palnuts. Similar practice is employed on the larger lower drive mounting pad, retaining the accessory with nuts and palnuts on the attaching studs. See figure 65.

b. DUAL ACCESSORY DRIVE DISASSEMBLY AND REMOVAL.

(1) Make sure the dual accessory drive housing is accessible by removing all lines from the accessories driven by that unit. Remove the palnuts, nuts, and washers from the attaching studs on each of the two mounting pads and withdraw the accessories or cover plates with their gaskets. Remove the loose-fitting tongue drive adapters where utilized in the splined drive shafts. Break the lock wire and remove the special cap nuts and washers from the two studs extending from the supercharger rear housing cover through the upper left-hand side of the dual accessory drive housing. Remove the palnut, nut, and washer from the one remaining attaching stud on the right-hand side of the cover adjacent to the lower drive mounting pad.

(2) Remove the dual accessory drive cover and gasket by tapping on its sides with a rawhide mallet, being careful not to allow the spur gears to drop out of their bushings in the housing. Withdraw the upper and lower gears, after which the two intermediate gears may be removed, exposing the nuts holding the dual accessory drive housing to the supercharger rear housing cover.

(3) Remove the castellated nuts and washers from the two studs extending from the supercharger rear housing cover through the central portion of the accessory drive housing wall section. Break the lock wire and remove the shouldered nuts and washers, located at the corners of the housing, using an offset box-socket wrench (Tool No. 800684) and handle. See figure 66. Remove the acorn nuts and copper washers from the studs which extend from the bottom of the accessory drive housing through the supercharger rear housing and cover parting flanges. Remove the dual accessory drive housing and gasket from the supercharger rear housing cover by tapping with a rawhide mallet.

c. DUAL ACCESSORY DRIVE SPEED RATIO CHANGE.

(1) To change the speed ratio of the accessory drives to the crankshaft, it is necessary to replace the two gears in the primary gear train (identified by their large teeth) with two gears of the desired ratio. The primary gear train consists of the drive gear machined integral with a splined shaft, and the intermediate gear which is bolted to the driving gear of the secondary train (identified by their small teeth). See figure 67.

(2) Six cap screws are employed to retain the intermediate gears together. The drilled heads are lock-wired together and do not require washers.

d. DUAL ACCESSORY DRIVE INSTALLATION. —Prepare the supercharger rear housing cover to receive the dual accessory drive unit as follows:

(1) Remove the two pipe plugs from the lower left-hand corner of the dual accessory drive mounting pad on the supercharger rear housing cover, thus uncovering holes for the dual accessory drive gear lubrication oil to drain into the supercharger rear housing. Remove the two flat head bolts extending through the supercharger rear housing and cover parting flanges at the lower right-hand corner of the dual accessory drive mounting pad. Remove the palnuts and nuts from two supercharger rear housing cover attaching studs immediately above the countersunk flat head bolt holes and from the adjacent attaching stud at the left of the countersunk holes. Remove the palnuts and nuts from the four studs holding the cover plate over the spare accessory drive shaft and withdraw the cover plate and gasket. Place a dual accessory drive mounting pad gasket over the studs now exposed.

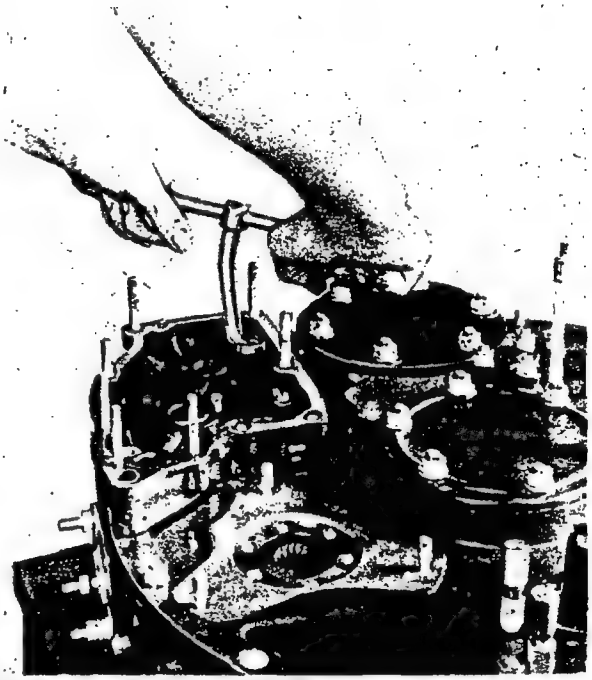

Figure 66—Loosening or Tightening Hidden Nut in Dual Accessory Drive Housing

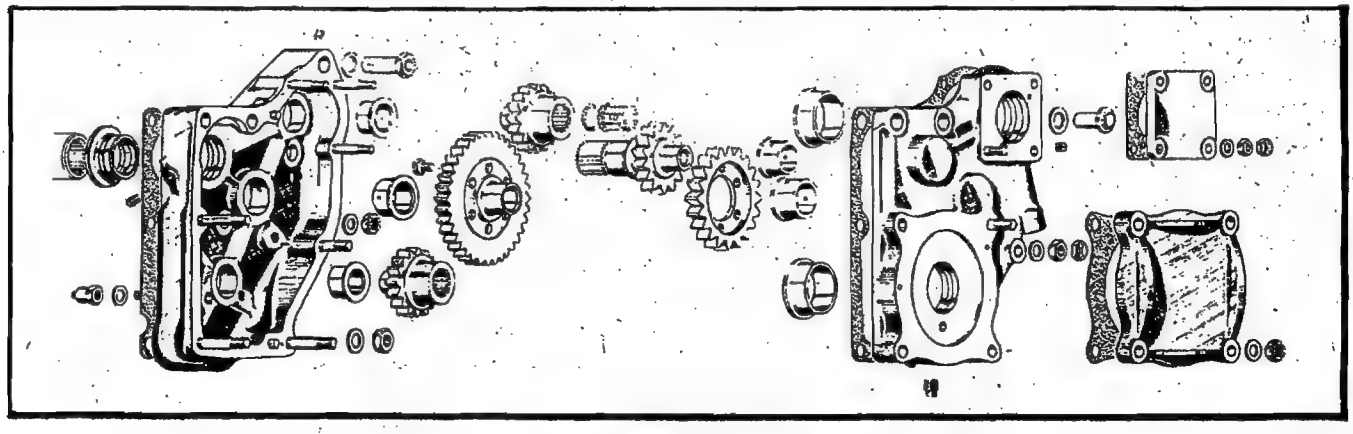

Figure 65—Dual Accessory Drive

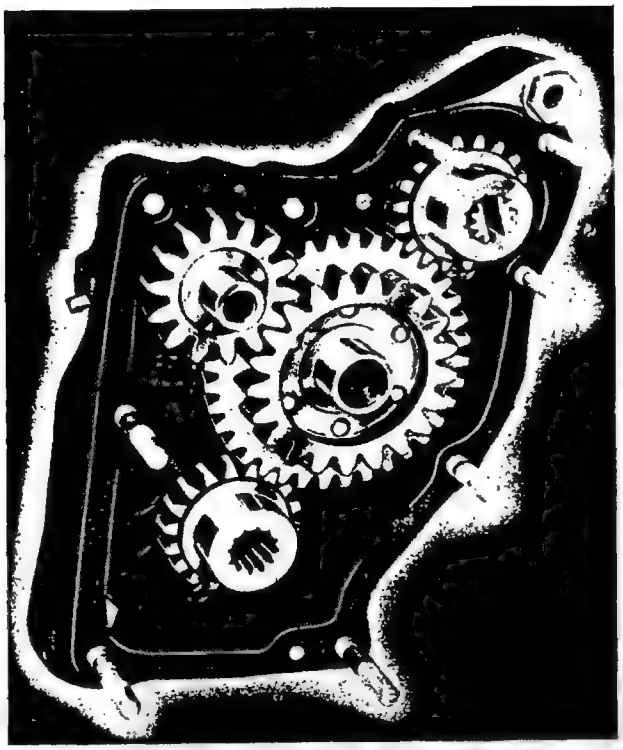

Figure 67—Dual Accessory Drive Gears

(2) Make sure the pipe plug has been removed from the tapped drain hole in the lower corner of the dual accessory drive housing. Place the housing in position on its attaching studs but do not push it all the way on to its mounting pad until the nuts are started on the studs under the over-hanging parting flange. The three supercharger rear housing cover attaching studs at the outer corners of the accessory drive housing utilize plain washers and special shouldered nuts requiring the use of an offset box-socket wrench and handle. The two studs extending from the supercharger rear housing cover through the central part of the accessory drive housing employ plain washers and castellated nuts. The castellated nut in the center of the housing is cottered and the other four nuts are lockwired. Install copper washers and acorn nuts on the two studs which extend from the bottom of the accessory drive housing through the countersunk holes in the supercharger rear housing cover, and lockwire the drilled tips of the acorn nuts together.

(3) Oil the four bushings in the accessory drive housing with engine oil. Place the primary drive gear (large teeth) in mesh with its intermediate gear and insert the two gears together into their supporting bushings in the accessory drive housing. The upper and lower accessory drive gears may then be placed in the housing, taking care to have the gear with involute splines and short front journal in the upper blind bushing and the gear with square splines and long front journal in the lower open bushing. Timing marks are not necessary on any of the spur gears making up the dual accessory drive.

(4) Install a gasket on the dual accessory drive housing parting surface and coat the gears with engine oil. Place the cover on its attaching studs and slide it forward over the rear journals of the gears. Place a plain washer and special cap nut on each of the two studs extending from the supercharger rear housing cover through the upper left-hand side of the accessory drive housing. Similarly install a plain washer and plain nut on the cover attaching stud located between the upper and lower drives. Tighten these nuts evenly, lockwiring the two special nuts together and installing a palnut over the plain nut.

(5) Install gaskets and accessories or cover plates on the two mounting pads following the instructions in applicable technical orders. Secure the accessories or cover plates with plain washers, nuts, and palnuts.

22. TACHOMETER AND OIL PUMP.

a. GENERAL.—The oil pump and tachometer assembly is located on the supercharger rear housing cover at the lower left-hand side. A mounting pad for an electric type tachometer and a screw-type connection for a mechanical-type tachometer is provided at the rear of the pump to the right of the oil pressure relief valve. See figure 68.

b. OIL PRESSURE RELIEF VALVE ADJUSTMENT.—Break the lock wire and remove the cadmium-plated steel cap and gasket from the oil pressure relief valve assembly located on the rear of the oil pump adjacent to the end plate. Loosen the large lock nut on the slotted adjusting screw to permit movement of the screw in either direction. Screwing in the clockwise direction increases the relief valve spring tension and engine oil pressure, and the opposite result is obtained by a counterclockwise movement of the adjusting screw. When the desired engine oil pressure has been obtained, tighten the lock nut against its shouldered copper gasket. Reinstall the steel cap and its shouldered copper gasket. Pressure regulation should be accomplished while the engine is in operation.

c. OIL PRESSURE RELIEF VALVE REPLACEMENT.

(1) Remove the oil pressure relief valve steel cap and lock nut with their shouldered copper gaskets as described in paragraph 22 *b*. Unscrew the slotted adjusting screw all the way off the bronze relief valve body, being careful not to accidentally lose the coiled spring which is immediately behind the adjusting screw. Remove this coiled spring and withdraw the steel piston from the bore of the bronze relief valve body. See figure 69.

(2) The relief valve body may be unscrewed from the aluminum alloy oil pump body by inserting the lugs of the wrench (Tool No. 83660) into the slots on the rear end of the relief valve body. Installation of a replacement bronze body is accomplished with the same tool. See figure 70.

(3) To assemble the unit, insert the hollow piston-type valve into the bronze relief valve body and place the coiled spring inside the piston. Screw the adjusting screw in approximately one-third of its length on the outside diameter of the bronze body over the extended end of the coiled spring. Install the lock nut

Figure 69—Oil Pressure Relief Valve

and its shouldered copper gasket loosely on the adjusting screw. Set the adjusting screw to give the desired engine oil pressure, tighten the lock nut, and install the steel cap and its gasket according to instructions in paragraph 22 *b* of this section.

d. OIL INLET CHECK VALVE REPLACEMENT.

(1) Break the lock wire and remove the cadmium-plated retainer from the left-hand side of the oil pump. Remove the copper-asbestos gasket, spring, and hollow piston from the bore of the bronze valve body.

(2) The bronze valve body is pressed into the oil pump body and cannot be removed in the field. The

Figure 68—Oil Pump

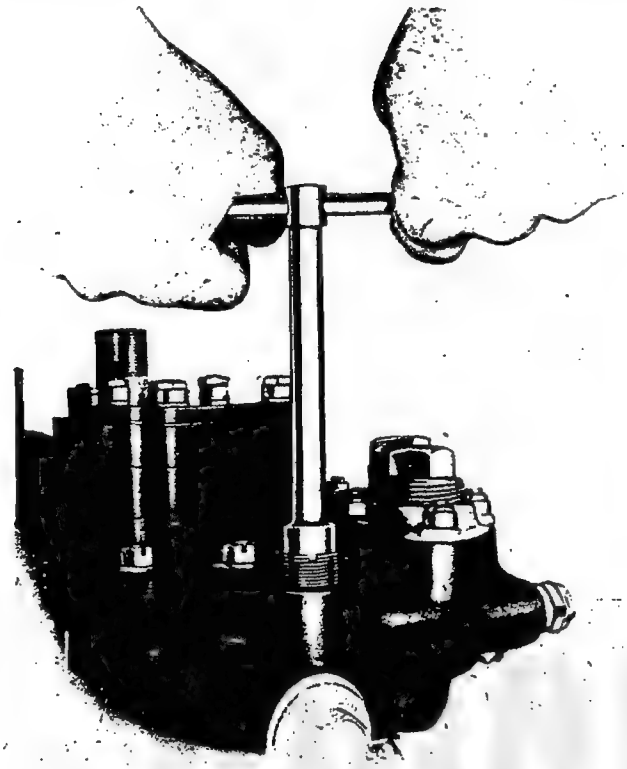

Figure 70—Removing Oil Pressure Relief Valve Body

steel piston employs one piston ring and may be replaced without the use of special tools. Expand the ring slightly and slide it over the chamfered end of the piston dome and into the piston ring groove. Refer to AN 02-35-1 for correct ring clearances and spring tension.

(3) Assembly is accomplished by inserting the piston and ring into the bronze check valve body, compressing the ring to permit entrance. Insert the spring into the hollow piston and screw on the retainer having a new gasket under the flange. Tighten and lockwire the retainer to prevent its loosening.

e. OIL PUMP REMOVAL.

(1) Unscrew the temperature bulbs from the inlet and outlet chambers of the oil pump. Remove the oil inlet and outlet oil lines and remove the tachometer connections.

(2) Break the lockwire and remove the special shouldered cap screw using wrench (Tool No. 800684) from the attaching leg at the right of the oil pump. Break the lock wire and remove the nuts and washers from the eight long attaching studs and remove the pump. Support the pump to prevent separation of the covers and housings. Temporarily retain the housings and covers by installing two long bolts of the same diameter as the mount studs.

f. OIL PUMP INSTALLATION.

(1) Place a new gasket over the long oil pump attaching studs, making sure the oil holes line up correctly. Coat the oil pump drive shaft coupling with a petrolatum, Specification AN-VV-P-236, and install the pump over the attaching studs, meshing the coupling with the splined end of the drive shaft in the supercharger rear housing cover. Install the plain washers and castellated nuts on the attaching studs. Tighten and lockwire the nuts together. Place a plain washer under the head of the special shouldered cap screw which secures the attaching leg of the oil pump to the supercharger rear housing cover. Lockwire the cap screw.

(2) Reinstall the tachometer cables, oil lines, and temperature bulbs on the pump.

(3) If it is found necessary to readjust the oil pressure relief valve to obtain the desired pressure, remove the steel cap from the valve body, loosen the lock nut, and turn the adjusting screw clockwise to increase the pressure. The pressure regulation should be accomplished while the engine is in operation. Tighten the lock nut and reinstall the steel cap. Insure that the shouldered washer is installed under the cap.

23. CUNO AUTOMATIC FILTER REPLACEMENT.

a. The Cuno automatic filter is attached to the left-hand side of the supercharger rear housing slightly below its midsection.

b. Removal of the filter is accomplished by breaking the lock wire and removing the three shouldered attaching cap screws. It may be necessary to tap the filter *lightly* with a rawhide mallet to effect removal if the filter is stuck. See figure 71.

NOTE

To prevent damaging the exposed filter cartridge, exercise care not to strike the cartridge against the sides of the filter hole.

c. Removing the extended cap nut on the outer face of the filter head exposes a pinion shaft which is provided to turn the filter manually for test or inspection purposes. Reverse the cap nut and screw it on the end of the pinion shaft thus providing a means of turning the filter.

d. Reinstall the cap nut in its original position on the pinion shaft bushing and lockwire it to the tab on

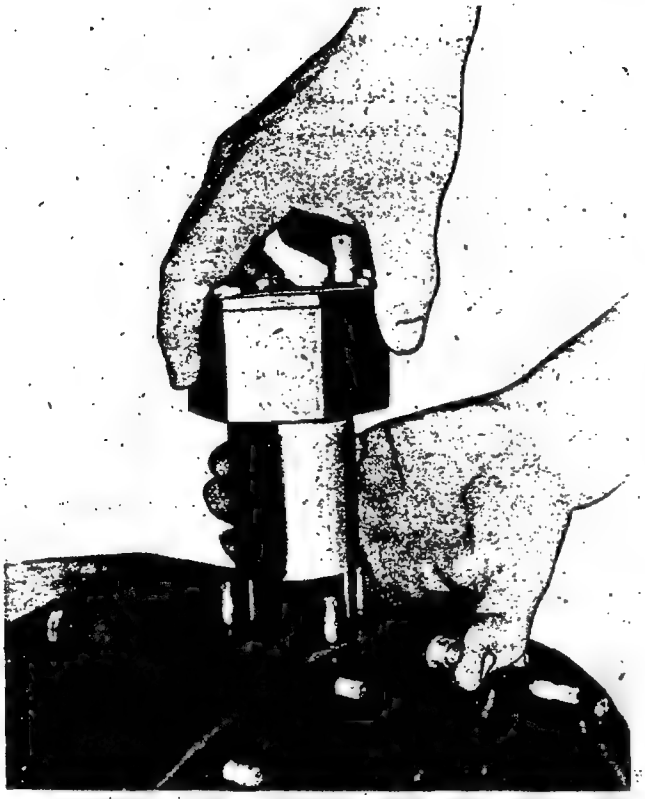

Figure 71—Removing Cuno Oil Filter

the special locking plate beneath it. See figure 72. Insert the filter in its recess in the supercharger rear housing, with its inner end fitting snugly in the supporting boss at the center of the supercharger rear housing cover. Make sure a new gasket is installed under the head of the filter. Insert the three retaining cap screws, tighten, and lockwire together.

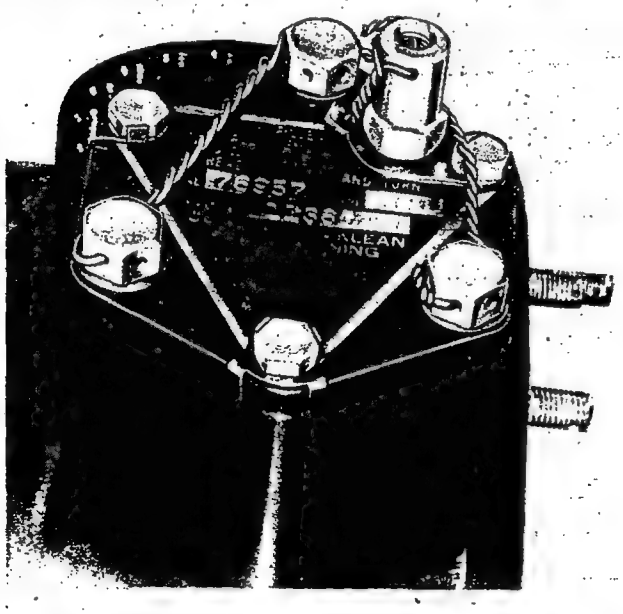

Figure 72—Method of Lockwiring Cuno Filter

24. SUPERCHARGER DRAIN VALVE.

a. STANDARD TYPE.

(1) REMOVAL.

(a) Disconnect the drain line from the outlet connection of the supercharger drain valve, located on the lower right-hand side of the supercharger rear housing. Remove the drain valve assembly by unscrewing the steel body out of the shouldered bronze bushing in the supercharger rear housing. This steel body is provided with hexagonal flats on its shank to accommodate an open end wrench. See figure 73.

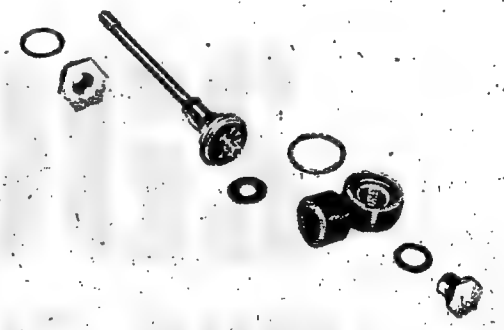

Figure 73—Supercharger Drain Valve—Exploded View

(2) INSTALLATION.

(a) Insert the drain tube into its passage in the lower right-hand side of the supercharger rear housing where it is retained by screwing the steel body into the shouldered bronze bushing, using the hexagonal flats milled in the shank of the body. Swing the aluminum alloy drain valve housing into the desired position for attaching the drain line, and secure it by tightening and lockwiring the drain valve retaining plug. Connect the drain line to the outlet nipple in the aluminum alloy drain valve housing.

b. TURBO TYPE.

(1) REMOVAL.

(a) Disconnect the drain line from the outlet connection in the drain valve housing. Break the lock

wire securing the valve housing to the supercharger rear housing, and unscrew the valve housing from the valve body. Take care not to drop the piston and disk unit which may remain either with the valve body or in the valve housing. Remove the piston and disk unit. Using the special wrench, unscrew the valve body from the supercharger rear housing, and withdraw the body and tube assembly as a unit.

(2) INSTALLATION.

(a) Install two new rubber packing rings in the groove at the small end of the valve body, and one below the flange at the large end of the body. If the drain valve is not assembled, place the piston and disk unit on the valve body. Assemble the housing to the valve body.

(b) Insert the complete assembly in the supercharger rear housing, using a washer between the flange on the valve body and the supercharger rear housing. Lockwire the drain valve housing to the supercharger rear housing, and install the drain line in the valve housing outlet.

25. SUPERCHARGER OIL SEAL VENT.

a. At the forward end of the supercharger rear housing adjacent to the carburetor adapter, is located the supercharger oil seal atmosphere vent fitting. This fitting consists of a hollow hexagonal head steel plug having breather holes drilled under the head and a fine mesh brass screen over the bottom of the pipe-threaded shank. Outwardly it resembles a large cap bolt screwed part of its length into the supercharger rear housing.

b. This vent fitting may be removed from the supercharger rear housing for cleaning or replacement. Use thread compound, Specification No. 3590, on the threads when reinstalling, being careful not to clog the fine brass screen on the inner end.

26. GUN SYNCHRONIZERS.

a. Refer to the Table of Differences for engines incorporating gun synchronizers.

b. Impulse generators for two guns synchronized to fire through the propeller are mounted, one on each side of the supercharger rear housing, with the exception of the model R-1820-97 engine, on which only the right-hand impulse generator is mounted. The installation of an external propeller governor oil supply line on the early model R-1820-97 engine replaces the left-hand gun synchronizer impulse generator drive. Each impulse generator drive shaft is driven at propeller speed through spiral gear teeth on the inner end which mesh at right angles with teeth cut in the shank of each magneto drive shaft.

c. The three cap screws and plain washers, which secure the dummy synchronizers with which the engine is shipped, are also used to secure the impulse generators and drive shaft supports.

27. PROPELLER GOVERNOR REPLACEMENT.

a. The propeller governor is mounted on a propeller governor adapter on the crankcase front section, employing an oil-resistant gasket on the governor mounting pad. Four run-fit attaching studs are used which bottom in blind bushings inserted in the propeller governor adapter. Plain washers, castellated nuts, and lock wire are used to secure the governor to the attaching studs.

b. When installing or replacing the propeller governor, a wrench or stud driver should not be used when installing the run-fit attaching studs. Screw each stud, with the fingers only, until its top bottoms in the blind receiving bushing.

SECTION VII
SERVICE TOOLS

Tool No.	*Nomenclature*
80292	Handle—Bar
80440	Clamp—Piston ring
81403	Handle—7/16 in. diameter, hollow
81900	Wrench—Valve clearance adjusting and rocker arm clamp screw 3/8 in. hex.
82058	Wrench—Oil sump strainer and rear cover cleanout plug lug
82284	Turning Tool—Propeller shaft
82703	Removing Tool—Push rod
82750	Wrench—Cylinder hold-down nut offset box 9/16 in. hex.
82860	Wrench—Cylinder hold-down nut box 1/2 in. hex.

Tool No.	*Nomenclature*
82889	Wrench—Propeller shaft thrust ball bearing nut lug
83243	Removing Tool—Piston pin
83517	Disk—Timing
83533	Adapter—Timing disk
83660	Wrench—Oil pressure relief valve body lug
84258	Wrench—Intake pipe packing nut lug
84414	Wrench—Spark plug socket 1 in. hex.
84450	Wrench—Spark plug socket 7/8 in. hex.
84501	Screw—Cylinder to crankcase locating 9/16 in. hex.
84566	Wrench—Rocker box cover nut removing, socket speed hand 7/16 in. hex.
84770	Removing Tool—Rocker box cover washers magnetic
84861	Installing Tool—Piston pin retaining spring
84922	Wrench—Torque (pivot handle)
84956	Puller—Fuel pump drive shaft support removing
800684	Wrench—Dual accessory drive housing and oil pump foot to supercharger rear cover nut box 5/8 in. hex.
800907	Cover—Intake pipe packing nut
800909	Cover—Cylinder intake port
800947	Adapter—Timing disk
801534	Puller—Fuel pump drive shaft oil seal removing
802924	Sealer—Plastic-film bag heating iron (115 AC)
803299	Removing Tool—Piston pin
803837	Cover—Cylinder exhaust port

NOTE

This list is taken from the Tool Catalog which shall be referred to for additional information, illustrations, etc.

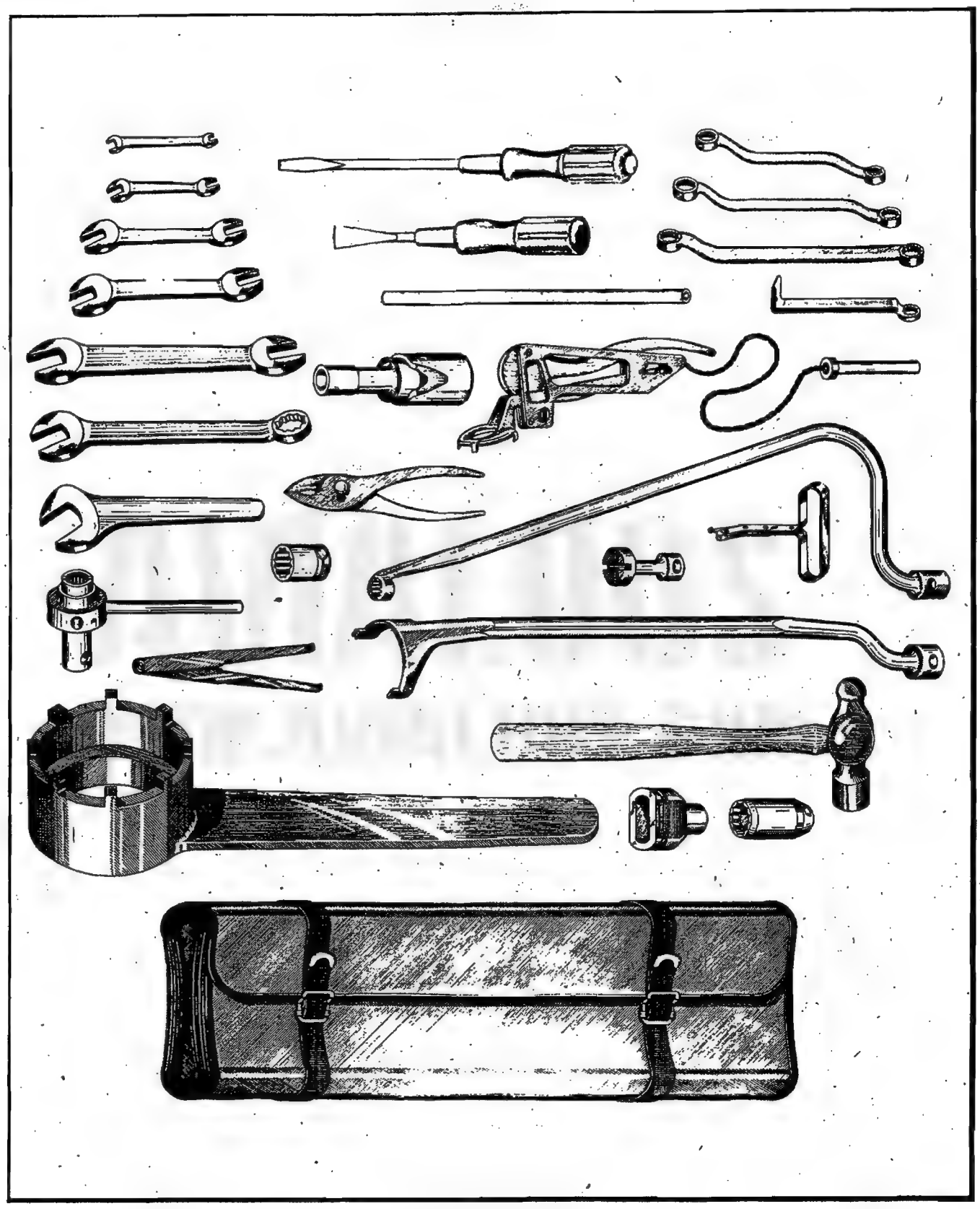

Figure 74—Tool Kit

APPENDIX I

American and British Aeronautical Nomenclature Referred to in this AN Handbook

American	*British Equivalent*	*Definition*
Aircraft	Aircraft	Any weight-carrying device designed to be supported by the air, either by buoyancy or by dynamic action. In Britain used only as a collective plural, and in the United States as either a singular or a collective plural.
Airdrome, airfield, or airport	Aerodrome	A definite and limited area of ground or water intended to be used in connection with the arrival, departure, and servicing of aircraft.
Airplane	Aeroplane	A mechanically driven aircraft heavier than air, fitted with fixed wings, and supported by the dynamic action of the air.
Angle, propeller-blade, or blade angle	Blade angle	The acute angle between the chord of a propeller section and the plane of rotation.
Antifriction Bearing (See Bearing, ball)		
Area, total propeller—disk	Disk area	The area of the circle described by the tips of the blades.
Automatic mixture control (Brit.) (See Control, altitude mixture)		
Axis, vertical	Normal axis or vertical axis	An axis at right angles to the horizontal plane of the longitudinal and lateral axes, and passing through their intersection.
Ball bearing (See Bearing, ball)		
Bearing, antifriction, ball bearing, or roller bearing	Ball bearing or roller bearing	A bearing designed to eliminate sliding friction by balls or rollers, which have only rolling contact with the cones and races.
Cap screw (See Screw, cap)		
Carburetor	Carburettor or carburetter	A mechanical device for mixing liquid fuel and air in the proper proportions to form a combustible mixture.
Check valve (See Valve, check)		
Clevis	Fork joint, knuckle joint end, or clevis	A device, usually consisting of a forked piece of metal with the ends perforated to receive a pin, used to fasten the end of a rod to another part of a structure.
Club, test	Test fan	A dummy propeller used in testing engines.
Cone, split, or split wedge	Collet	Cone section used to lock a valve spring collar onto a valve stem.

American	*British Equivalent*	*Definition*
Cone, union	Union nipple	A joint that is brazed onto the end of a pipe.
Control, altitude mixture	Mixture control, automatic mixture control, or altitude control	A device on a carburetor for regulating the proportions of air and fuel supplied to an engine at different altitudes.
Cotter pin (See Pin, cotter)		
Efficiency, propeller	Net efficiency	The ratio of the thrust power to the input power of a propeller.
Engine, geared	Geared motor or geared engine	An engine in which the power developed is transmitted to the propeller shaft through gears.
Engine or power plant	Aero-engine	An engine used to provide the motive power for an aircraft.
Exhaust manifold (See Ring, exhaust collector)		
Exit	Egress or exit	A passage out of a place.
Fillister screw (See Screw, fillister)		
Filter, screen or strainer (oil)	Filter	A porous material or a unit through which engine oil is passed to cleanse and strain it.
Flat-head screw (See Screw, flat-head)		
Friction, skin	Surface friction	The tangential component of fluid force at a point on a surface.
Fuel (See Gasoline)		
Fuel gage (See Gage, fuel)		
(to) Gall	(to) Fret	To damage or wear by an oscillating motion, as in the case of splines.
Gasket	Joint, washer or gasket	A sheet or ring of packing used for pipe joints, engine heads, and similar purposes.
Gasoline, "gas," or fuel	Petrol or fuel (preferable)	A volatile, inflammable, liquid hydrocarbon mixture used as a fuel.
Geared engine (See Engine, geared)		
Generator	Dynamo	A machine by which mechanical energy is changed into electrical energy.
Gross weight (See Weight, gross)		
Ignition harness (Brit.) (See Shield)		
Kerosene	Paraffin, kerosene, or petroleum	An illuminating oil distilled from petroleum.

American	*British Equivalent*	*Definition*
Lean	Weak	Of a mixture of air and gasoline vapor, deficient in the gasoline vapor.
Left	Port	Situated to the left, looking in the direction of motion of an aircraft.
Locknut (Brit.) (See Palnut)		
Lock ring (See Ring, lock)		
Lock washer (See Washer, lock)		
Lock wire (See Wire, lock)		
Manifold pressure (See Pressure, manifold)		
Manifold pressure regulator (See Regulator, manifold pressure)		
Mixture control (Brit.) (See Control, altitude mixture)		
Nipple, union	Union	A coupling for pipes and fittings, facilitating connection or disconnection.
Nut, spanner	Ring nut	A ring-shaped nut with notches in the outer circumference.
Oil, slushing, or slushing compound	Corrosion inhibitor	A semi-solid oil or grease used as a protective coating for bright metal surfaces.
Pad	Accessory mounting face	A raised machined surface on an engine, upon which accessories may be mounted. (May include end of drive shaft.)
Palnut	Lock nut (type of)	A very thin nut used to bind another nut and prevent it from loosening.
Paraffin	Paraffin wax or paraffin	A waxy, inflammable substance produced in distilling wood, lignite, or coal.
Pin, cotter	Split pin	A split cotter, the ends of which are bent after insertion through the cotterway.
Pin, knuckle	Wrist pin or anchor pin	The pin in the bearing attachment of an articulated connecting rod to the master connecting rod.
Pin, piston	Gudgeon pin or piston pin	A round shaft used in the pin bearing connection between the piston and connecting rod.
Piston pin (See Pin, piston)		
Plugs, spark	Sparking plug	A unit holding the positive and negative electrodes which form the spark gap in a combustion chamber.

American	*British Equivalent*	*Definition*
Pressure, manifold	Boost pressure or boost	The pressure in the induction system at a point standardized for each type of engine. "Manifold pressure," on American installations, is usually measured in inches mercury absolute; on British installations, however, it is known as "boost pressure," and is measured in pounds per square inch above or below standard sea-level atmospheric pressure.
(to) Prime	(to) Prime or dope	To operate a pump which squirts raw gasoline into the intake passages or cylinders to facilitate starting.
Propeller	Airscrew (obsolete), propellor, or propeller	A power-driven bladed screw designed to produce thrust by its rotation in the air.
Propeller, adjustable	Adjustable-pitch airscrew (obsolete) or adjustable-pitch propellor	A propeller whose blades are so attached to the hub that the pitch may be changed while the propeller is at rest.
Propeller, controllable	Controllable-pitch airscrew (obsolete), variable-pitch airscrew (obsolete), controllable-pitch propellor, or variable pitch propellor	A propeller whose blades are so mounted that the pitch may be changed while the propeller is rotating.
Rated engine speed (See Speed, rated engine)		
Regulator, manifold pressure	Boost control unit or automatic boost control unit	An automatic device which so regulates the throttle that a predetermined boost pressure is not exceeded.
Right	Starboard	Situated to the right, looking in the direction of motion of an aircraft.
Ring, exhaust collector, or exhaust manifold	Exhaust ring or exhaust manifold	A circular duct into which exhaust gases from the cylinders of a radial engine are discharged.
Ring, lock, or snap ring	Circlip	A spring-wire ring, usually to retain a spanner nut or piston pin in place.
Rod, articulated	Auxiliary connecting rod	A connecting rod used in a radial engine in conjunction with a master connecting rod.
Roller bearing (See Bearing, ball)		
Round-head screw (See Screw, round-head)		
Run, green	Running-in	Operation of a newly built mechanism long enough and at the proper speeds to control the first wear that occurs, so that subsequent service operation may be satisfactory.
Safety wire (Brit.) (See Wire, lock)		
Screen (ignition) (See Shield)		

American	*British Equivalent*	*Definition*
Screen (oil) (See Filter)		
Screw, cap	Set screw	A threaded bolt used generally without a nut to secure a cap or cover.
Screw, fillister	Cheese-headed screws	A screw whose head is cylindrical and slotted, with a convex or flat top.
Screw, flat-head	Countersunk-head screw	A screw with a flat head, which is bevelled on the lower side so as to fit into a countersink.
Screw, round-head	Round-head screw or cup-headed screw	A screw with a hemispherical head.
Setscrew or headless set-screw	Grub screw	A headless machine screw, screwed through one part tightly upon another part to prevent relative movement.
Slushing compound (See Oil, slushing)		
Socket or plughole	Socket	A fixed female fitting for making electrical connections by the insertion of a plug.
Socket wrench (See Wrench, socket)		
Spanner nut (See Nut, spanner)		
Spanner wrench (See Wrench, box-end)		
Spark plug (See Plug, spark)		
Speed, calibrated air	Indicated air-speed (A.S.I.)	The reading of the air-speed indicator, corrected for instrumental and installation errors.
Speed, critical	Stalling speed	The lowest speed of an aircraft at which control can be maintained.
Speed, indicated air (IAS)	Air-speed-indicator reading	The reading of the air-speed indicator.
Speed, minimum	Minimum flying speed	The minimum air-speed at which an airplane can be maintained in level flight.
Speed, rated engine	Maximum rpm for continuous cruising	The highest speed of an engine at which its reliability has been determined for continuous performance.
Stack	Pipe (single)	A single pipe, usually an exhaust pipe, from an engine cylinder to the atmosphere or to a manifold.
Tachometer	Engine speed indicator (E.S.I.), tachometer, revolution indicator, or rev. counter	An instrument which measures revolutions per minute of an airplane engine.
Tag	Label or tag	A slip of paper, cloth, or metal affixed to anything and indicating the contents, ownership, destination, rating, or designation.

American	*British Equivalent*	*Definition*
Test after overhaul (Brit.) (See Test, block)		
Test, block	Test after overhaul	The test given an airplane engine generally after overhaul but before installation in the airplane.
Test Club (See Club, test)		
Thrust, propeller	Airscrew thrust (obsolete), or propellor thrust	The component parallel to the propeller axis of the total air force on the propeller. Its symbol is T.
Valve	Cock or valve	Any device by which the flow of liquid or gas may be started, stopped, or regulated.
Valve, check	Non-return valve or check valve	A valve which permits flow in one direction but prevents a return flow.
Vent	Vent-pipe	A pipe leading from the air space in a fuel, oil, or coolant tank to the atmosphere.
Vise or Vice	Vice	A device having two jaws closed by a screw to hold work.
Washer (Brit.) (See Gasket)		
Washer, lock	Spring washer	An open, spiral, spring-tampered steel washer for preventing the loosening of nuts.
Wire, lock	Safety wire	A wire used to secure a small part so that it cannot loosen.
Wrench	Spanner or wrench	An instrument for exerting a twisting load, as in turning bolts or nuts.
Wrench, box-end, closed spanner wrench or spanner wrench	Ring spanner	Any wrench with a ring-shaped end into which the nut fits.
Wrench, monkey	Screw-spanner	A straight-handle wrench having one fixed jaw set at right angles to the handle and one adjustable jaw.
Wrench, socket	Box spanner	A section of hexagonal tubing which fits over a nut and which is turned by means of a bar passed through its upper end.

APPENDIX II

TIGHTENING TORQUE VALUES

STANDARD STUDS, BOLTS, SCREWS, AND CAP SCREWS

				Torque Values			
				Driving Stud		Tightening Nut, Screw, or Cap Screw	
Name	*Size of Thread Nut End*	*Min. Diam of Thread Root or Neck (In.)*	*Min. Rockwell Hardness*	*Minimum In. Lb*	*Maximum In. Lb*	*Minimum In. Lb*	*Maximum In. Lb*
Button-Head Screw	10-32	.1467	B-50	.....	.....	20	25
Button-Head Screw	12-24	.1585	B-50	.....	.....	25	30
Studs, Bolts, Screws and Cap Screws	10-32	.1467	C-19	.....	.....	35	40
"	12-24	.1585	C-19	.....	.....	45	50
"	1/4-28	.180	C-26	50	70	80	85
"	5/16-24	.229	C-26	100	150	160	175
"	3/8-24	.285	C-26	200	275	225	250
"	7/16-20	.331	C-26	300	425	350	375
"	1/2-20	.387	C-26	500	700	550	600
"	9/16-18	.436	C-26	750	975	825	875
"	5/8-18	.493	C-26	1100	1400	1125	1200

STANDARD PRACTICES FOR SPECIAL APPLICATIONS

Cyl Hold-Down Stud	3/8-24	.313	C-32	325	450	350	375
Cyl Hold-Down Cap Screw	7/16-20	.330	C-26	.....	.....	375	400
Cyl Hold-Down Stud	7/16-20	.331	C-32	400	550	425	450
Rocker Hub Bolt	7/16-20	.371	C-32	.....	.....	250	325
Rocker Hub Bolt	15/32-20	.400	C-19	.....	.....	250	325
Rocker Hub Bolt	9/16-1[illegible]	.488	C-26	.....	.....	300	375
Spark Plug	18 mm	.....	.....	.....	.....	300	360